Determinants of Foreign Direct Investment:
An empirical investigation into sources of attraction

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Determinants of Foreign Direct Investment:
An empirical investigation into sources of attraction

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Two roads diverted in a wood, and I—
I took the one less traveled by,
And that has made all the difference.

Robert Frost, *The Road Not Taken*

Voorwoord

Dit boek markeert het einde van een lang traject. Het was niet de meest gebruikelijke weg. Maar toen ik een paar jaar geleden voor de keuze werd gesteld: stoppen of doorgaan met het proefschrift, heb ik bewust voor het laatste gekozen. Dat het proefschrift nu, na zoveel jaren, dan toch eindelijk af is geeft mij bijzonder veel voldoening. Terugblikkend kan ik constateren dat de weg naar voltooiing van het proefschrift evenzeer de moeite waard was als het bereiken van het uiteindelijke doel. Ik heb onderweg veel geleerd, niet alleen wat betreft het doen van wetenschappelijk onderzoek. Dit alles maakt dat ik mij bijzonder gelukkig prijs met dit boekje. Het citaat op de pagina hiernaast drukt dit gevoel – voor mij – op treffende wijze uit.

Op dit punt beland, wil ik graag iedereen bedanken die dit traject op de een of andere manier samen met mij heeft afgelegd of heeft bijgedragen aan de voltooiing van het proefschrift. De ruimte hier is te beperkt om iedereen persoonlijk te bedanken, maar een ieder die een exemplaar van dit boek heeft ontvangen is op zijn/haar eigen wijze belangrijk geweest bij de totstandkoming ervan. Een aantal mensen verdient echter een speciale vermelding.

In de eerste plaats Henri de Groot. Beste Henri, ik ben jou ontzettend veel dank verschuldigd. Na het debacle met het oude manuscript ben ik, enigszins per toeval, bij jou terecht gekomen. Dat bleek een schot in de roos! Jij hebt het aangedurfd om de zaak opnieuw op te pakken. In eerste instantie hebben we gekeken of we voort konden bouwen op het oude onderzoek. Maar na verloop van tijd zijn we een geheel nieuwe richting ingeslagen. We zijn dus feitelijk helemaal opnieuw begonnen. Regelmatig ben ik, na overleg, jouw kamer uitgelopen met het gevoel van de spreekwoordelijke bel en de klepel. Maar deze “huh?”-momenten werden na verloop van tijd stelselmatig gevolgd door een “aha-erlebnis”. Ik kreeg als het ware een abstracte schets van waar ik naartoe moest, het was vervolgens aan mij om uit te zoeken hoe daar te komen. Ik heb die manier van werken als heel stimulerend en prettig ervaren. Daarnaast ben je iemand die oog heeft voor een ander. Om een voorbeeld te geven: ik was verbaasd hoe goed je – zonder dat ik daar ook maar iets van heb gezegd – de spanning die toch weer even de kop opstak toen het proefschrift bij de commissie lag en de opluchting toen de goedkeuring daar was, hebt aangevoeld én dat ook verwoordt. Dat siert je als mens. Ik ben daarom blij dat we onze samenwerking kunnen voortzetten door mijn aanstelling als post-doc aan de VU. In de tweede plaats ook heel veel dank aan Eelke de Jong. Beste Eelke, na een eerste, grove afbakening van het nieuwe onderwerp ben jij als promotor in het project gestapt. Met zijn drieën hebben we vervolgens de details van het project ingevuld. Daarna ben ik aan de slag gegaan met het onderzoek. Ik ben blij dat ik de volgende promovendus ben die onder jouw begeleiding met succes een promotie afrondt. Daarnaast wil ik je graag

bedanken voor de tijdelijke aanstellingen als docent aan de Radboud Universiteit Nijmegen. Deze hebben bijgedragen aan het financieren van deze hele onderneming.

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Vera en Rosalinde, lieve paranimfen. Ik heb niet lang hoeven nadenken wie ik zou vragen als paranimf. Jullie zijn beiden zelf gepromoveerd. En jullie hebben altijd enthousiast meegeleefd. Vera, jij was er zelfs al bij in Maastricht! Het geeft mij veel vertrouwen jullie bij de verdediging aan mijn zijde te weten.

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Dank ook aan ooms en tantes, neven en nichten, die over de jaren heen hebben meegeleefd en regelmatig hebben geïnformeerd naar mij en de stand van zaken rondom het proefschrift. Ik waardeer dat enorm.

Strings, a special word of thanks to you for the wonderful job you did in designing the cover. I think you are a great designer and you're a dear friend. I am looking forward to many more of your classic one-liners in the future!

Het laatste woord tenslotte is voor hen die de meeste dank verdienen. Ik draag dit boek op aan mijn ouders. Lieve pap en mam, het heeft even geduurd en ik denk dat er momenten zijn geweest waarop jullie je afvroegen of het allemaal wel goed zou komen. Maar het is goed gekomen. Dank voor jullie liefde en onvoorwaardelijke steun, Maudje.

Maureen Lankhuizen
Amsterdam, juli 2009

Contents

List of Figures

List of Tables

1

Introduction and Motivation

1.1. Introduction

In *The world is flat*, Thomas Friedman warns us for the consequences of globalisation in the 21st century.[1] Because of much improved communication technologies, distance has become less important. As a result, our jobs are increasingly contested by far-away workers in China and India. The book is a huge success and was on the New York Times bestseller list for a long time.

Friedman addresses one of the key issues in (international) economics: what happens to the location of economic activity (who, where, what) when borders between countries disappear. Friedman's ominous take on the effects of globalisation is not shared by everybody, though.[2] According to the new economic geography (NEG), economic activity clusters in certain countries or regions (e.g., Fujita et al., 1999, Brakman et al., 2001). The reason is that, on the one hand, the location of activity in one or only a hand full locations, yields economies of scale. In addition, clustering yields benefits due to agglomeration. In a review of *The world is flat*, Leamer (2007) argues that relationships

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[1] The book is mainly written from the perspective of the U.S., but the message can easily be extended to all of North America, Europe and Australia.

[2] See Leamer (2007) for a review of *The world is flat*. Below, we only summarise the gist of Leamer's comments on Friedman's economic analysis.

rather than "markets" are the key in economic exchanges.[3] Most exchanges involve various degrees of organisation, contact (including face-to-face) and communication between buyers and sellers, and trust (cf. Williamson, 1975, on markets versus hierarchies). Relationships are to large extent a 'local' affair, whether physical, cultural or informational. Thus, the contestability of our labour markets is limited by 'geography'. As Leamer (2007, p. 92) puts it, "far-away, low-skilled workers [are] an unlikely alternative to nearby folks whom we have come to know and trust." The message of the NEG is that the impact of globalisation on the location of economic activity depends on the advantages of agglomeration relative to the benefits of moving to the periphery. The impact of globalisation will be limited if the advantages of agglomeration are large. Globalisation may even promote the clustering of economic activity if the costs of trading with the periphery decline (lower transport costs or lower trade barriers) relative to the benefits of agglomeration. If, on the other hand, agglomeration externalities are small, globalisation can have huge effects (Brakman et al., 2005). The NEG version of Friedman's rather ominous story about the consequences of globalisation in the 21st century is: it depends.

One important element has not yet been addressed in the discussion above: mobility of firms and production factors. This brings us to the role of multinational enterprises (MNEs). MNEs are key players in the global economy. Recent empirical facts by McCann (2008) illustrate the economic significance of multinational activity. Multinationals account for 10% of global GDP and 12.5% of global gross fixed capital formation. Multinational affiliate sales are 2.25 times the size of global exports. Multinational affiliate employment is 73 million (equivalent to 3% of global workforce). Finally, multinationals account for over half of global R&D and two thirds of private sector R&D.[4] Table 1.1 presents statistics on the growth in different indicators of multinational activity in the last two decades. The data are from UNCTAD's *World Investment Report* (WIR) 2007. The table indicates that MNE activity in the form of FDI has grown rapidly in the last two decades. The growth of FDI stocks and flows has exceeded the expansion of GDP, capital stocks and trade.[5]

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[3] "Countless faceless buyers meet countless faceless sellers, and carry out exactly the same transaction. … The exchange is completely impersonal." (Leamer, 2006, p. 99).

[4] Multinational activity is concentrated in a limited number of very large firms. For instance, 500 multinationals account for 90% of ($1.4 billion per annum) foreign direct investment (FDI) and 50% of global trade; 100 multinationals account for 10% foreign assets of multinational enterprises, 17% foreign sales, and 13% of total foreign employment.

[5] Global FDI flows fell sharply in 2001 and 2002 but growth resumed in 2003 (WIR 2003 and 2004).

Table 1.1. Selected indicators of multinational activity, 1986–2006

	Average annual growth rate (per cent)			
	1986–1990	1991–1995	1996–2000	2006
FDI inflows	21.7	22.0	40.0	38.1
FDI outflows	24.6	17.3	36.4	45.2
Inward FDI stock	16.9	9.4	17.4	19.4
Outward FDI stock	17.7	10.6	17.3	17.9
Sales of foreign affiliates	19.3	8.8	8.4	17.7
Exports of foreign affiliates	21.7	8.5	3.3	12.2
Employment of foreign affiliates (in thousands)	5.3	5.5	11.5	13.9
Comparison	Average annual growth rate (per cent)			
GDP (in current prices)	9.4	5.9	1.3	8.6
Gross fixed capital formation	11.5	5.5	1.0	13.1
Exports of goods and non-factor services	13.9	8.4	3.7	12.2

Source: UNCTAD, WIR 2007.

What is the impact of FDI on the distribution of economic activity across space? Empirical evidence (see, e.g., Brakman et al., 2001) reveals a strong clustering of activity across space.[6] What is the role of FDI in this? Does FDI lead to even more clustering of economic activity in important centres, thus increasing the gaps between countries? Or does it promote a more even spread of economic activities globally? These are interesting (from the perspective of the economic researcher) and important (from the perspective of society) research questions. These questions provide the background for this study. These questions demand that we understand what fundamental factors drive FDI location. That is the purpose of the present study.

1.2. Stylised facts

It is commonly understood that FDI arises from the possession by MNEs of firm-specific assets such as particular types of technology or organisational skills (cf. Dunning, 1980, 1988, 2001). These assets give the firm a competitive advantage in supplying any particular market or set of markets. Due to market failure connected with the assets (high

[6] The world is actually far from flat: the economic landscape has many hills and many valleys. See Nordhaus' spinning globe for a graphical representation, http://www.econ.yale.edu/~nordhaus/homepage/homepage.htm.

transaction costs and/or difficulties to (fully) appropriate rents), it is in the best interest of the firm to exploit the assets internally (i.e. within the boundaries of the firm) rather than to sell these or the right of use to some foreign-based enterprise. This entails setting up foreign production subsidiaries.

Besides internal motives, FDI is motivated by characteristics of host countries. The firm must have a reason to locate production abroad. The sources of location advantage are mixed. We can distinguish between market-seeking and efficiency-seeking FDI. In the case of market-seeking FDI, or horizontal FDI, the main motive is to access markets and to avoid transport costs and trade barriers. In the case of efficiency-seeking, or vertical, FDI, the main motive is to exploit factor-cost differences. In the description so far, FDI is primarily a means to *exploit* assets. However, FDI can also be asset-*seeking*. MNEs are increasingly looking across national borders to create or gain access to assets which complement their existing core competencies.[7] This is pertinent particularly in the sourcing of technological assets (Dunning, 2001). Asset-seeking FDI is attracted by rather different factors than asset-exploiting FDI (to which horizontal and vertical FDI belong). The former is attracted by human capital or (high-quality) innovation systems, factors that are rather similar to the characteristics in the home country that gave rise to the MNE in the first place. This study examines what characteristics make countries attractive locations for FDI.

Table 1.2 presents data on inward and outward FDI stocks as a percentage of GDP.[8] The table illustrates the size of investments from and into countries. The table first of all shows that the share of world inward and outward stock in GDP has increased steadily since 1980, as already suggested by the data on growth rates in Table 1.1. Second, Table 1.2 bears out stylised facts noted also by Markusen (2002). First, developed countries are net investors, while developing countries are net recipients of FDI.[9] Second, during the 1980s and 1990s, the least developed countries have inward FDI stocks that are smaller than the inward FDI stocks of developing countries as a whole. Most significant, these stocks are also below the world average. In other words, the least developed countries attracted little FDI. It is not until the year 2000 that inward FDI in the least developed countries catches up to the world average. However, looking at the inward and outward FDI stocks of countries as a percentage of their GDP hides a third important stylised fact concerning the distribution of FDI.

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[7] This is reflected in the increasing importance of mergers and acquisitions and strategic alliances since the second half of the 1990s (Dunning, 2001).

[8] The stylised facts below are an update of Section 1.3 in Markusen (2002). Those who have read Markusen's book will be familiar with the stylised facts presented below.

[9] Outward stocks in South, East and South-East Asia have increased substantially in the late 1990s. Still, they remain (well) below the world average to date.

Table 1.2. FDI stock as a percentage of GDP

	1980	1985	1990	1995	2000	2003
World						
- inward	6.6	8.3	9.3	10.2	19.3	22.9
- outward	5.8	6.6	8.6	10.0	19.1	23.0
Developed countries						
- inward	4.9	6.2	8.2	8.9	16.6	20.7
- outward	6.2	7.3	9.6	11.3	21.4	26.4
Developing countries						
- inward	12.4	16.3	14.7	16.3	29.3	31.4
- outward	3.6	3.6	3.8	5.7	12.4	12.2
Least developed countries[a]						
- inward	4.0	4.9	5.5	9.3	19.1	24.5
- outward	0.6	2.6	1.1	2.1	2.9	2.7
Africa						
- inward	8.2	9.8	10.9	15.4	24.6	25.3
- outward	2.2	4.1	5.3	7.3	8.6	6.6
Latin America and the Caribbean						
- inward	6.5	11.0	10.4	11.7	25.6	36.8
- outward	6.5	7.7	5.5	5.2	7.9	10.7
South, East and South-East Asia						
- inward	27.4	24.6	20.8	20.8	36.6	34.6
- outward	1.0	1.0	2.6	6.7	18.1	15.9

Source: UNCTAD, WIR 2004.
[a] UN definition.

Table 1.3 gives the distribution of total world FDI stock in the period 1980–2006 by (groups of) source and destination country. The data are again from the WIR 2007. The first column of Table 1.3 indicates that developed economies account for the bulk of total outward FDI: the share amounts to almost 90 per cent of total outward FDI stock in the period 1980–2006. In other words, the developed countries are the major source of outward FDI. Within the group of developed economies, the OECD countries are the main investors. South, East and South-East Asia, the second largest source of outward FDI, accounts for only 7 per cent of total outward FDI. At the same time, Table 1.3 indicates that developed countries, and notably the OECD, are also the main recipients of FDI.[10] The share of the developed countries in inward FDI is lower than in the case of outward FDI, but they nevertheless account for over 70 per cent of total inward FDI.

[10] FDI is largely 'regional' as well: over 70 per cent of sales of the top 500 MNEs are within the same region, e.g., EU, NAFTA, ASEAN (McCann, 2008).

Table 1.3. Pattern of world FDI stock in 1980–2006 (percentage share in total)

	Outward	Inward
Developed economies	88	72
- OECD	85	70
South, East and South-East Asia	7	14
- East Asia[a]	6	9
- South-East Asia[b]	1	4
- South Asia[c]	0	1
South and Central America	2	7
Africa	1	3
South-East Europe and the CIS (Transition economies)	1	2

[a] Including, China, Hong Kong, Korea.
[b] Including, Indonesia, Malaysia, Philippines, Singapore, Thailand.
[c] Including, Bangladesh, India, Sri Lanka.
Source: UNCTAD, WIR 2007.

Table 1.4 gives the distribution of inward and outward FDI stock across countries in selected years. The table shows that the role of East Asia as a source and recipient of FDI has increased since 1995, led in particular by China (including Hong Kong). Nevertheless, the predominance of developed economies as the main source and destination of FDI is rather persistent over time. The predominance of developed economies as the main source and destination of FDI implies that FDI flows foremost between developed countries. Data on bilateral FDI of the OECD in the period 1982–1992 confirm this: 87 per cent of outward FDI stock is with other OECD-countries.[11] Summing up the statistics presented above we arrive at the following stylised facts:

1. Developed countries are the main recipients of FDI. The least developed countries attract relatively little FDI (at least during the 1980s and 1990s);
2. Developed economies are not only the main recipients but also the main source of FDI.
3. FDI is foremost between developed, high-income countries. This stylised fact follows logically from the first two.

[11] These data will be described in more detail in Chapter 3.

Table 1.4. Pattern of world FDI stock in selected years (share in total)

	1980	1985	1990	1995	2000	2006
Developed economies						
Outward	0.88	0.89	0.92	0.89	0.86	0.86
Inward	0.75	0.72	0.79	0.75	0.69	0.70
- OECD						
Outward	0.83	0.86	0.91	0.88	0.85	0.82
Inward	0.75	0.74	0.80	0.75	0.69	0.64
East Asia [a]						
Outward	0.02	0.02	0.03	0.05	0.08	0.07
Inward	0.05	0.05	0.05	0.07	0.12	0.10
South-East Asia [b]						
Outward	0.00	0.00	0.01	0.02	0.01	0.01
Inward	0.03	0.04	0.04	0.05	0.05	0.04
South Asia [c]						
Outward	0.00	0.00	0.00	0.00	0.00	0.00
Inward	0.00	0.00	0.00	0.00	0.00	0.01
South and Central America						
Outward	0.08	0.07	0.03	0.02	0.02	0.02
Inward	0.06	0.07	0.05	0.06	0.07	0.06
Africa						
Outward	0.01	0.01	0.01	0.01	0.01	0.00
Inward	0.07	0.05	0.03	0.03	0.03	0.03
South-East Europe and the CIS (Transition economies)						
Outward	0.00	0.00	0.00	0.00	0.00	0.01
Inward	0.00	0.00	0.00	0.00	0.01	0.03

[a] Including, China, Hong Kong, Korea.
[b] Including, Indonesia, Malaysia, Philippines, Singapore, Thailand.
[c] Including, Bangladesh, India, Sri Lanka.
Source: UNCTAD World Investment Report 2007.

1.3. Aim and structure of the study

The aim of this study is to explain the distinct pattern of world-wide FDI presented by the stylised facts in the previous section. Why do some countries attract large amounts of FDI, whilst others attract only small amounts? What are the fundamental factors that drive FDI? We introduce the following overall research question to serve as a guideline for the analysis: what are the sources of attraction for FDI?

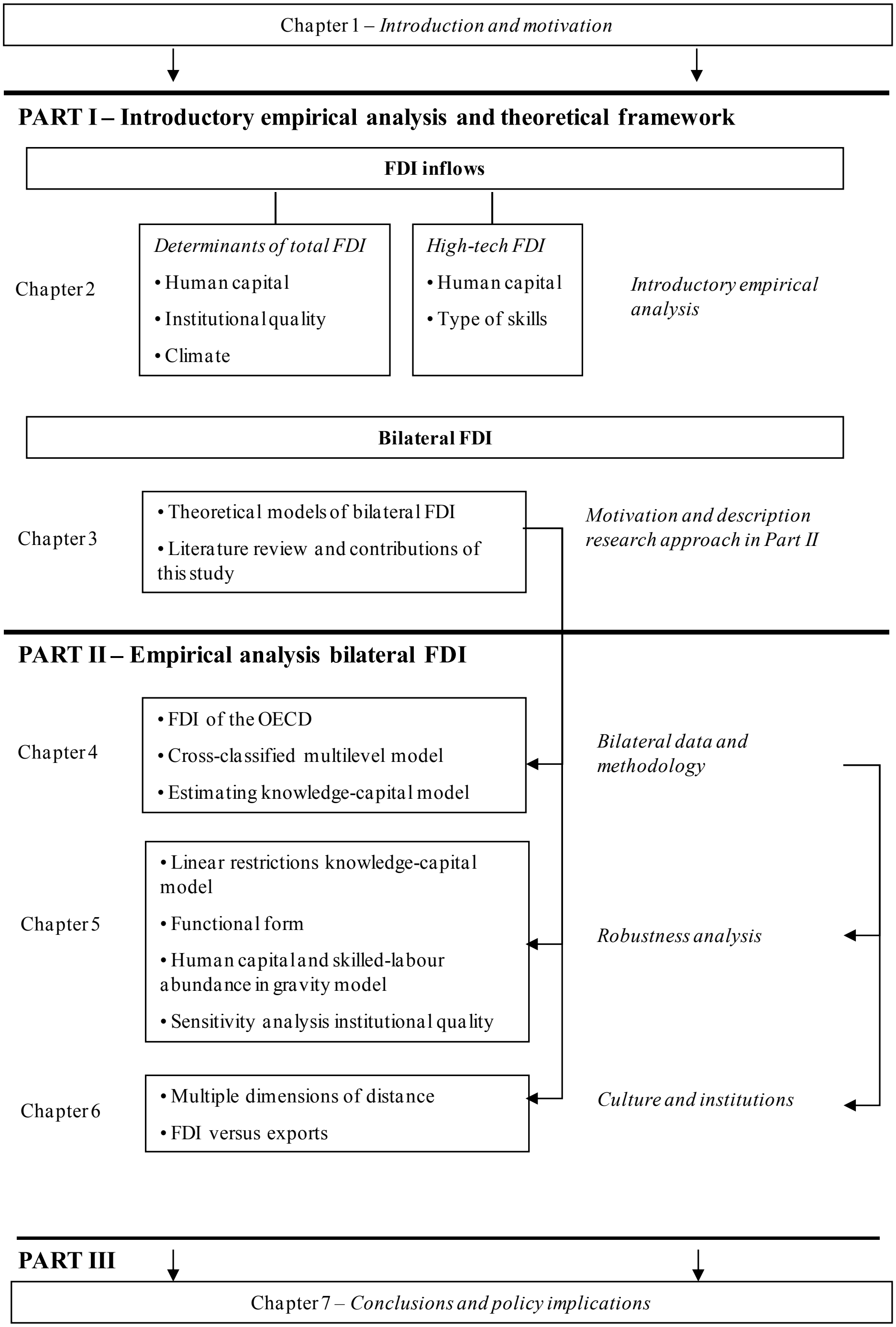
Figure 1.1 provides a graphical outline of the study. Overall, the study is made up of three parts that are interlinked in the following manner. Part I consists of Chapters 2 and 3. Chapter 2 serves as a first introductory empirical analysis in the investigation into the sources of attraction for FDI using data on FDI inflows. The analysis is not based on an explicit theoretical framework. The latter is given in Chapter 3. Chapter 3 presents general equilibrium models of bilateral FDI. Chapter 3 subsequently motivates and describes the approach in Part II. Part II contains our empirical analysis of bilateral FDI. Part II consists of Chapters 4–6. Part III concludes, considers implications for policy and suggests areas for further research.

The chapters are organised as follows. Chapter 2 empirically investigates the stylised fact that developed countries attract the bulk of FDI whilst the least developed countries attract only a little. What factors can explain this marked pattern in world-wide FDI? The chapter investigates the importance of human capital, inflation, institutional quality and geographic characteristics in attracting FDI inflows by host countries. These factors are regarded important determinants of economic development in the literature on economic growth. To what extent do they explain the variation in FDI inflows across host countries? The main contribution of Chapter 2 is its additional investigation of the role of human capital in attracting FDI. In the new growth theory, human capital is considered to be important with respect to technological progress. In view of that, we investigate whether human capital is more conducive to attracting FDI in technology-intensive sectors than total FDI. We also investigate whether attracting FDI in technology-intensive sectors requires a particular *type* of skills, namely technical as opposed to managerial skills. For this purpose, we use new indicators of human capital. We look at enrolment in science; enrolment in engineering, manufacturing and construction; and enrolment in social sciences, business and law.

Chapter 3 first of all presents two main theoretical models of bilateral FDI, i.e., the knowledge-capital model by James Markusen and co-authors (Markusen et al., 1996, Markusen, 1997 and 2002) and the proximity-concentration trade-off hypothesis by Lael Brainard (Brainard, 1997). The presentation of the models is followed by a critical review of the two models and the empirical work related to them. Subsequently, Chapter 3 presents the extensions and contributions to the existing literature of the present study and gives an outline of the empirical analysis in Part II. Chapter 3 also introduces the gravity model. The gravity model is the most commonly used model in the empirical literature to explain variation in trade or investments between countries. Furthermore, the chapter discusses lessons from the empirical literature on the importance of culture and institutions as intangible barriers to trade and investment.

One of the contributions in Part II pertains to the data. We use data on bilateral FDI of the OECD. The advantage of the OECD data is that it substantially increases the number of observations on bilateral FDI compared to using data that are bilateral with the U.S. only. Key contributions in the previous empirical literature on bilateral FDI reviewed in Chapter 3 use data that are bilateral with the U.S. only. These studies use data on affiliate sales. Detailed data on the activities of foreign affiliates is available for the U.S., but is often sparse or unavailable for other countries. This entails an increase in the number of

Figure 1.1. Structure of the study



observations on bilateral FDI by two-thirds compared to using data that are bilateral with the U.S. only.

Chapter 4 is largely methodological in nature. An issue in the data used in Part II is dependence. The data is a panel data set for multiple parent and host countries. There are several repeated observations: for parents over all host countries, for host countries over all parents, for parent and host countries over time, and for specific parent-host combinations. This study uses multilevel techniques to account for clustering of observations of FDI within parent and host countries and parent-host combinations. Chapter 4 explains the multilevel approach and illustrates the approach by fitting a multilevel version of the knowledge-capital model to the bilateral FDI data of the OECD. In Chapters 5 and 6, multilevel estimation is used as an additional robustness analysis to take account of clustering.[12]

In Chapter 5 we empirically examine the specification of the knowledge-capital model. The distinctive feature of the knowledge-capital model is that, within aggregate FDI, it distinguishes between horizontal and vertical FDI. To capture the distinction between horizontal and vertical FDI, the empirical specification imposes a particular structure on the data. In Chapter 5 we test the robustness of the empirical specification of the knowledge-capital model for the OECD data. Are the linear constraints imposed in the empirical specification supported by the data? And how appropriate is the linear form of the model? In the second part of the chapter we estimate a gravity model of bilateral FDI. With respect to skilled labour we distinguish measures of human capital and skilled-labour abundance.

Chapter 6 investigates empirically the effect of different dimensions of distance on the choice between export and FDI as alternative modes of serving foreign markets. Conventional proximity-concentration theory suggests that FDI substitutes for trade if distance between countries is large, while exports become more important if scale economies in production are large. Chapter 6 extends the framework for analysing the trade-off between exports and FDI empirically. Our approach explicitly takes into account intangible barriers related to cultural and institutional differences. Unlike the mechanisms described by the proximity-concentration trade-off, these 'intangible' barriers can affect the costs related to FDI as well as trade. We estimate gravity equations for total foreign sales (sum of exports and sales related to FDI) and the share of FDI-sales in total sales. For this purpose we derive a proxy variable for FDI-related sales in the foreign market by using capital-output ratios.

Chapter 7 summarizes the main findings from this study and links the conclusions from this study back to the question posed at beginning of this section, i.e., regarding the sources of attraction for FDI. We also present policy implications and suggest areas for further research.

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[12] This is indicated by the arrows on the right-hand side of Figure 1.1.

Part I

Introductory Empirical Analysis and Theoretical Background

2

Determinants of FDI Inflows

2.1. Introduction

The stylised facts presented in Chapter 1 indicate a distinct pattern of FDI at the macro-level: developed countries are the main source of FDI but also the main recipients; least developed countries attract only little FDI. What factors explain this marked distribution of FDI inflows across host countries? Why do developed countries attract the bulk of FDI whilst the least developed countries attract so little? This chapter investigates FDI inflows, regardless of where they come from. With this, we relate to an extensive, but in general somewhat earlier, literature on cross-country FDI regressions (see, e.g., Chakrabarti, 2001, for a survey of the most cited studies).[13] The chapter serves as a first introductory empirical analysis in the investigation into the sources of attraction for FDI. In this chapter we examine the importance of a number of factors that are important determinants of economic development in the empirical growth literature (e.g., Barro, 1997 and 2000): human capital, inflation, institutional quality and geographic

[13] Most recent empirical studies on FDI use bilateral FDI data (see, e.g., Blonigen, 2005, for a survey). Yet, bilateral FDI data have been available only fairly recently. In Part II of this study we use bilateral FDI data.

characteristics. To what extent do these factors explain the variation in FDI inflows across host countries?

The main contribution of this chapter is its additional investigation of the role of human capital in attracting FDI. In the new growth theory, human capital is considered to be important with respect to technological progress (e.g., Nelson and Phelps, 1966, Benhabib and Spiegel, 1994, Barro and Sala-i-Martin, 1995, Ch. 8). In view of that, we investigate whether human capital is more conducive to attracting FDI in technology-intensive sectors than total FDI. Furthermore, we investigate whether attracting FDI in technology-intensive sectors requires a particular *type* of skills, namely technical as opposed to managerial skills. For this purpose, we use new indicators of human capital. We look at: enrolment in science; enrolment in engineering, manufacturing and construction; and enrolment in social sciences, business and law.

The chapter is organised as follows. Section 2.2 motivates the selection of the explanatory variables. Section 2.3 presents the econometric framework. Section 2.4 presents the results of the model estimations for total FDI. Section 2.5 looks at the effect of human capital on inflows of high-tech FDI. The importance of the type of skills in attracting high-tech FDI is investigated in Section 2.6. Section 2.7 concludes.

2.2. Motivation of explanatory variables

Human capital, inflation, institutional quality and geographic characteristics are commonly regarded as important determinants of economic development in the literature on economic growth. In this section, we build on the arguments in the growth literature and indicate why human capital, inflation, institutional quality and geographic characteristics may also be relevant for FDI. We emphasise that the selection of explanatory variables in the empirical analysis in this chapter is not tied back to a specific theoretical model of firm decision making.[14] As mentioned above, we are interested to know what factors can account for the fact that *developed* countries attract more FDI. That is, what distinguishes developed countries from other countries? Our point of departure for this analysis, therefore, is the macro-perspective: what are important determinants of economic growth established by the literature? For the factors identified in this manner, we then assess whether they may also be relevant for FDI, in the sense that they represent an important condition for FDI or act as a barrier.

The theoretical underpinnings for the role of human capital in economic development are given by the 'new growth' models. Important contributions in this area have been made by Romer (1986, 1990), Grossman and Helpman (1989, 1991) and Aghion and Howitt (1990). In new growth models long-run growth is driven by endogenous

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[14] The latter is given in Chapter 3.

technological change.[15] Technological progress is generated by investments in knowledge by forward-looking, profit-maximising, firms. These investments lead over time to new and better products and improved production methods. Human capital is important in new growth models because it is a key input in the production of new knowledge. An abundance of well-educated human resources also helps to facilitate the absorption of advanced technologies from developed countries (Barro and Lee, 2000). In the convergence literature, growth rates in less advanced countries are, in part, explained by a catch-up process in the level of technology. In a typical model of technology diffusion, backward countries achieve substantial technological progress and reduce the technology gap with leading countries by assimilating superior production techniques developed in the more advanced countries and by modernising obsolete plants and equipment accordingly. As a result, they will gradually catch up with technological leaders. However, the convergence literature goes on to note that less advanced countries do not unequivocally catch up with advanced countries: in order to assimilate foreign technology, countries need absorption capacity.[16] This means that the level of technology that a country is able to assimilate from elsewhere depends on the current level of knowledge in the country. One of the factors determining countries' absorption capacity most commonly recognised in the convergence literature is human capital. In addition to the importance of human capital in economic development through technological progress (the new growth models), the level and distribution of educational attainment also has a strong impact on social outcomes, such as child mortality, fertility, education of children and income distribution (Barro and Lee, 2000).

Why would human capital be relevant for FDI? As described in Chapter 1, multinationals account for about two thirds of private sector R&D. Second, they produce, own and control most of the world's advanced technology (e.g., Blomström and Kokko, 2003). To the extent that multinationals acquire this technology from existing firms in other countries (through mergers and acquisition), they will invest predominantly in host countries with an abundance of human capital since these are the countries that generate this type of firms. To the extent that multinationals set up new plants in a host country, the latter needs sufficient human capital to adopt the advanced technology of the multinational.[17]

Besides such 'positive' growth determinants like human capital, the growth literature distinguishes a number of factors that represent risks and costs, and that accordingly may

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[15] A key feature in these models is the notion of knowledge as a partially public good (cf. Romer, 1986). There may be spill-overs from the original inventor to other firms because knowledge cannot be perfectly patented or kept secret. The creation of new knowledge by one firm is thus assumed to have a positive external effect on the production possibilities of other firms.

[16] Lankhuizen (2000) investigates the absorptive capacity of the Baltic States after their independence in the early 1990s. The paper investigates whether the Baltics have the capacity to become 'Bal-techs'.

[17] Markusen (2002) assumes that branch plants of foreign multinationals are more skilled-labour intensive than the economy as a whole, especially in developing countries. See Chapter 3 for a more detailed analysis.

hamper economic growth. In a similar vein, the factors may also impose costs on or pose risks to FDI. Such factors are discussed in the next paragraphs.

A category of factors that is considered an important condition for economic growth is macroeconomic stability. Inflation has received considerable attention in the literature.[18] Barro (2000) shows that inflation has a negative, direct effect on economic growth. Furthermore, the rate of inflation also has a significantly negative effect on the investment ratio. With respect to FDI, inflation represents the cost disadvantage from macroeconomic instability in the host country suffered by multinational firms.

The impact of institutions has received a lot of attention in the literature on economic growth and development (e.g., Hall and Jones, 1999, Acemoglu et al., 2001, Rodrik et al., 2002).[19] Institutions influence the uncertainty surrounding transactions and hence the costs associated with this. As a result, they are recognised as variables that affect productivity and economic growth. Institutions are relevant for FDI for much the same reason. The quality of institutions in a host country affects expropriation risks, securing of intellectual property rights, the degree of corruption, the enforceability of private contracts, and the security of investment in general. In this way, they affect the cost of doing business in a foreign market. The impact of institutions has received increasing attention in the literature on FDI. Some studies investigate the impact of corruption, finding a negative effect on FDI (Wei, 2000a). Others have included more comprehensive measures of institutional quality to capture investment barriers. For instance, Globerman and Shapiro (2003) confirm that institutional quality in the host country has a positive effect on inward investment.

Geography (location and climate) can affect the level of development through three channels (Gallup et al., 1999). Location has an impact on income levels and income growth through its effect on transport costs (e.g., Gallup et al., 1999, Mellinger et al., 2000): coastal economies will generally have much lower transport costs than landlocked economies and countries near core economies will generally have lower transport costs than distant countries. These lower transport costs have a positive effect on income and income growth because (i) they lower the price of capital goods because some investment goods must be imported and/or (ii) they lower the price of importing intermediate inputs in export processing activities. In the words of Gallup et al. (1999): “almost all modern production depends on multistage processing of output, with inputs often produced in many specialized enterprises. The low-cost transport of such intermediate products is crucial, especially in developing countries, where many intermediate components are imported” (Gallup et al., 1999, p. 190). Second, climate affects income and income

[18] Other macroeconomic factors with impact on growth that have received a lot of attention in the literature are fiscal policy, budget deficits and tax burdens.

[19] Burnside and Dollar (2000) find that institutions are important for less developed countries to benefit from development aid. Ederveen et al. (2002) perform a similar analysis for the European Structural Funds. They reach similar conclusions: on average the Structural Funds are ineffective. Yet, for countries with the ‘right’ institutions they are effective.

growth through its effect on productivity (e.g., Gallup et al., 1999, Mellinger et al., 2000): infectious diseases (like malaria) are heavily concentrated in tropical ecological zones. In the former two cases, geography has a direct effect on economic development. Third, geography can have an indirect effect on economic development through its influence on the choice of economic policies (e.g., Gallup et al., 1999)[20] or on institutions (e.g., Acemoglu et al., 2001, Wei, 2000b). Wei (2000b) shows that countries in unfavourable geographic circumstances (e.g. in terms of climate, inland waterways and distance to the coast) do not have the incentive to invest in good institutions in contrast to countries that are naturally more open. The case by Acemoglu et al. (2001) on the impact of geography on institutions is more indirect. They argue that lower mortality (related to the local disease environment) at the time of colonisation encouraged permanent settlements by European colonists and the subsequent implementation of European institutions. These early institutions have persisted over time.

2.3. Data and method

In order to investigate the importance of human capital, inflation, institutional quality and geographic characteristics in attracting FDI inflows by host countries, we use a simple model in which market size is the main control variable alongside the variables of interest. Market size, measured by GDP, is generally considered a key determinant of FDI (see, e.g., Chakrabarti, 2001, Markusen, 2002).[21]

The specification for our analysis looks as follows:

$$\log TotalFDI_i = \beta_0 + \beta_1 \log GDP_i + \beta_2 \log HC_i + \beta_3 \log Stability_i + \beta_4 Geographic_i + \varepsilon_i \tag{2.1}$$

The dependent variable $TotalFDI_i$ is the simple average of annual FDI inflows in current US$ over the period 1995–2004. Data were taken from the *International Financial Statistics* (IFS) Online of the International Monetary Fund. GDP was calculated as the simple average over the period 1995–2004. Data are from the World Development Indicators. The data are in current US$.

We use the indicator of labour-force quality constructed by Hanushek and Kim (1995) as a proxy for human capital (*HC*). In the empirical literature on economic growth and FDI, the measures of educational attainment from the Barro and Lee (1993 and 1996)

[20] Gallup et al. (1999) estimate that coastal economies may be more likely to adopt open trade policies.

[21] Markusen distinguishes between horizontal and vertical FDI (see Chapter 3 for a detailed presentation of the so-called knowledge-capital model). Market size of the host economy has a positive effect on both types of FDI.

dataset on education are commonly used indicators of human capital. However, the Barro and Lee indicators merely measure the *quantity* (years) of schooling. They do not adjust for quality differences across countries. As observed by Hanushek and Kim, "few people would believe that a year of secondary schooling in the U.S. was equivalent to a year at the same grade level in Egypt" (Hanushek and Kim, 1995, p. 2). Hanushek and Kim have constructed a measure of schooling *quality* based on student cognitive performance on various international tests of academic achievement. The measure, henceforth denoted by *QL*, combines all the information on international mathematics and science tests available for countries from 1965 through 1991.[22] Performance series are observed for 39 countries, but Hanushek and Kim extend these quality measures to other countries by imputing missing values from international test score regressions.

Macroeconomic instability is proxied by inflation. Inflation is the average annual growth (in percentage) of the GDP deflator over the period 1995–2004. Data are from the World Development Indicators Online 2006. We use institutional quality as an indicator that equally reduces costs, but it is a more encompassing measure of stability of the macro environment than inflation. Data on institutional quality are from the database constructed by Kaufmann et al. (2005). Kaufmann et al. have constructed six indicators of perceived institutional quality. These indicators are: voice and accountability; political stability; government effectiveness; regulatory quality; rule of law; control of corruption. Institutional quality is calculated by taking the simple average of the scores across all six indicators. Next, we took the average over the period 1996–2004.[23]

Lastly we include a number of geographic characteristics. We use two variables. The first variable is a dummy variable indicating whether countries are landlocked.[24] This variable proxies physical transport costs. The second variable, *climate*, is the percentage of population living in temperate ecozones. Data are from Mellinger et al. (2000).

High-tech FDI

As explained in Section 2.2, in the new growth theory human capital is particularly important for technological progress. Sectors differ according to the possibilities for technological progress. The OECD Classification of High-Technology Products and Industries lists products (at the 5-digit level) according to R&D intensity (R&D expenditures/total sales). It considers aerospace, computers and office machinery, electronics, instruments, pharmaceuticals, electric machinery, chemicals, non-electrical

[22] In order to be able to make comparisons of performance over time, performance series are benchmarked to the U.S. performance on the NAEP.
[23] The aspects of institutional quality are highly positively correlated. An investigation using Cronbach's alpha suggests that all indicators reflect the same underlying characteristic and can be combined into a single measure (De Groot et al., 2004).
[24] Information was obtained from the CIA factbook (www.cia.gov/cia/publications/factbook).

machinery and armament as product categories with high-tech products.[25] Marasco (2005) finds that the stock of human capital is important for attracting high-tech FDI.

We are interested to see whether human capital (proxied by the Hanushek and Kim (1995) measure of schooling quality as before) is more important in high-tech FDI than total FDI. Using the OECD product classification as a point of reference, we investigate the importance of human capital for FDI inflows in ISIC Rev.3 sector 29 (machinery and equipment) and sector 30, 31, 32 (electrical and electronic equipment).[26] The indicators are the simple average of annual FDI inflows in the period 1995–2004. Data are from the UNCTAD FDI/TNC database.

So far, we have used a proxy of human capital *in general*. Depending on the type of FDI, however, specific knowledge is required. So, a measure taking into account different *types* of human resources would be more appropriate. This study uses new indicators of human capital. We look at: enrolment in science; enrolment in engineering, manufacturing and construction; and enrolment in social sciences, business and law. This distinction enables us to examine whether technical skills are more important than, e.g., managerial skills in attracting high-tech FDI. The data are the average percentage (of total enrolment) of students in tertiary education (ISCED levels 5–6) enrolled in science, engineering, manufacturing and construction, and social sciences, business and law, respectively, in the period 1998–2004. Data were taken from the UNESCO Global Education Digest 2005 CD-Rom.[27]

The number of observations for high-tech FDI is quite small, limiting the degrees of freedom. Therefore, we initially estimate the following equations:

$$\log FDIMachinery_i = \beta_0 + \beta_1 \log GDP_i + \beta_2 \log HC_i + \varepsilon_i \tag{2.2}$$

$$\log FDIElectrical_i = \beta_0 + \beta_1 \log GDP_i + \beta_2 \log HC_i + \varepsilon_i \tag{2.3}$$

The variables of macroeconomic uncertainty/stability, i.e. inflation and institutional quality, are added as part of a sensitivity analysis. Descriptive statistics of the variables included in the regressions are presented in Appendix 2A.

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[25] The list is the outcome of calculations concerning R&D intensity (R&D expenditures/total sales) for six countries, United States, Japan, Germany, Italy, Sweden and the Netherlands (European Commission, 1997).

[26] These are the high-tech sectors for which most data were available. Not all products in these categories are in fact high-tech. Yet, data at a more detailed level are not available for a wider set of countries.

[27] UNESCO uses national data. Hence, the data may contain a certain degree of noise due to differences in classifications across countries. Also, school enrolment "reflects current flows of education, and the accumulation of these flows will be one element in the stocks of human capital that will be available later" (Barro and Lee, 1993, p. 2).

2.4. Results total FDI

This section presents the results of the model estimations for total FDI. We have complete observations for 69 countries. Table 2.1 shows the results.

In the first specification, we regress FDI inflows on the level of GDP. The results indicate that market size is an important factor in explaining FDI inflows. The coefficient is positive and highly significant. This is true for any specification in Table 2.1. What's more, GDP alone explains over 60 per cent of the total variation in FDI inflows across countries.

The next specification includes institutional quality. The coefficient is positive and statistically significant, indicating that institutional quality is an important determinant of FDI inflows. Nevertheless, the magnitude of the coefficient on institutional quality in specification (2) is somewhat overestimated. The coefficient on institutional quality in specification (2) captures some of the effect of the omitted human capital and geographic characteristics. This is illustrated in the next two specifications. Specifications (3) and (4) add human capital and geographic characteristics. The coefficient on institutional quality is now smaller and has a somewhat lower significance level.

The coefficients on human capital and climate have the expected positive sign in specifications (3) and (4). The landlocked dummy has a positive coefficient. Being landlocked is expected to be a particular disadvantage for developing countries (see Section 2.2 above). If we distinguish the least developed countries as a separate group in the regressions, we do indeed find a negative effect of the landlocked variable for this group, whilst the effect is positive for the other countries.[28] On the whole, adding human capital and the geographic characteristics adds little additional explanatory power: the share of the explained variation increases only slightly. The coefficients on human capital and geography have low significance levels. The results indicate that, when institutional quality is controlled for, we can be less confident that human capital and, especially, climate contribute to FDI inflows. The reason is intuitively clear: countries with high institutional quality most likely also have the highest level of human capital and are located in temperate climate zones.[29]

[28] There are three landlocked developing countries in the sample. At the same time, there are landlocked European countries like Luxembourg and Switzerland that attract a lot of FDI. This explains why the overall effect is positive (though insignificant). Because a Chow-test (see below) indicates that do not differ significantly between the least developed countries on the one hand and other countries (developed and developing) on the other (i.e., no structural break), we do not report the regression results separately.

[29] See the correlation matrix in Appendix 2A.

Table 2.1. Determinants of total FDI inflows

	Specifications (1) – (7): pooled regression							Sub-samples	
								Most developed countries	Other countries
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log GDP	0.85***	0.64***	0.63***	0.67***	0.76***	0.78***	0.77***	0.63***	0.75***
	(12.51)	(7.20)	(7.03)	(7.84)	(9.97)	(10.14)	(10.16)	(4.43)	(8.19)
Log Human capital			0.81	0.73	1.63***		0.98	–5.32**	1.37
			(1.06)	(0.86)	(2.73)		(1.22)	(2.90)	(1.57)
Institutional quality		0.92***	0.76**	0.66**				2.45***	0.58
		(3.87)	(2.61)	(2.65)				(4.50)	(1.59)
Log Inflation					–0.29*	–0.28*	–0.22		
					(1.84)	(1.81)	(1.55)		
Climate				0.15		1.11***	0.73	2.18	–0.15
				(0.34)		(3.08)	(1.48)	(1.24)	(0.32)
Landlocked				0.60		0.88*	0.84	0.87	0.53
				(1.28)		(1.83)	(1.62)	(0.69)	(1.33)
Constant	–13.94***	–8.97***	–11.68***	–12.44***	–17.29***	–12.12***	–15.53***	7.98	–16.80***
	(7.97)	(4.18)	(3.30)	(3.43)	(6.74)	(5.98)	(4.87)	(0.74)	(4.98)
Adjusted R^2	0.61	0.71	0.72	0.72	0.71	0.72	0.73	0.53	0.58
Observations	69	69	69	69	69	69	69	22	47
Log likelihood	–118	–108	–107	–106	–109	–107	–105	–24	–71

Robust (absolute) *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

In specifications (5) – (7) we proxy macroeconomic instability by inflation. Inflation has the expected negative coefficient. It is significant at the 10 per cent level in specifications (5) and (6) and nearly significant in (7). Human capital and geography are statistically significant in specifications (5) and (6), respectively. Controlling for inflation, human capital and geography all at once (specification (7)) explains up to 73 per cent of the total variation in FDI inflows, but the variables are no longer significant statistically.

Discussion of results

Of the specifications in Table 2.1 our preferred specification includes measures of macro(economic) stability/certainty, human capital and geographic characteristics simultaneously. Not including these variables simultaneously causes omitted variable bias as the variables are correlated (see Table 2A.3 in Appendix 2A). Thus we are looking at either specification (4) or (7). Specification (4) is our most preferred specification for two reasons. First, institutional quality is estimated to have a positive and rather robust effect on FDI inflows across all its specifications. Second and related to the first point, the fact that institutional quality is not included in specification (7) probably biases the coefficients on human capital and climate upwards.

The relation between GDP, human capital and inflation on the one hand, and FDI inflows on the other is expressed in a logarithmic form. The coefficients on these variables in Table 2.1 thus reflect elasticities. For instance, in specification (4), a 1 per cent increase in GDP raises FDI inflows on average by an estimated 0.67 per cent. The relation between institutional quality, climate and the landlocked dummy and FDI inflows cannot be log-linearised. The indicator of institutional quality varies between 1.91 and –1.17. The landlocked dummy assumes values of either 0 or 1, and the indicator of climate can also assume the value of 0 (if the share of a country's population in temperate ecozones is zero). The coefficients on institutional quality, climate and the landlocked dummy in Table 2.1 reflect semi-elasticities. To interpret the impact of institutional quality and the geographic variables on FDI suggested by the semi-elasticities in specification (4), we use a measure of variation that is consistent with the respective samples, i.e. a change of one standard deviation from the mean. For instance, the mean institutional quality in the enrolment sample is 0.46, with a standard deviation of 0.90 (see the descriptive statistics in Appendix 2A). Given the semi-elasticity of institutional quality in specification (4) of 0.66, increasing institutional quality above its mean by one standard deviation would have an average impact on FDI of 81 per cent.[30]

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[30] This is computed as follows: $d\ln(TotalFDI_i) = 0.66 \times 0.9$ so $\dfrac{dTotalFDI_i}{TotalFDI_i} = e^{0.66\times 0.90} - 1 = 0.81$.

Increasing the climate variable above its mean is thus estimated to raise FDI inflows by almost 7 per cent. Being landlocked increases FDI inflows by an estimated 82 per cent.[31]

As a robustness check on the results in Table 2.1, we performed Chow-tests to investigate whether the impacts from the independent variables are the same across different groups of countries. We perform separate Chow-tests for two different sub-groups: the least developed countries and the most developed countries (using UN definitions to classify countries in one category or another). For the purpose of the Chow-test, we estimate the following specification of the model in equation (2.1):

$$\begin{aligned}&\log TotalFDI_i = \beta_0 + \beta_1 \log GDP_i + \beta_2 \log HC_i + \beta_3 \log Stability_i + \\ &\beta_4 Geographic_i + g_2 \times \beta'_0 + g_2 \times \beta'_1 \log GDP_i + g_2 \times \beta'_2 \log HC_i + \\ &g_2 \times \beta'_3 \log Stability_i + g_2 \times \beta'_4 Geographic_i + \varepsilon_i\end{aligned} \tag{2.1'}$$

In this specification, g_2 is a dummy variable indicating whether a country belongs to a certain category. Note that, if g_2 denotes whether a country belongs to the group of least developed countries (developed countries), the coefficients β_i indicate the effects of the explanatory variables ($i = 0, \ldots, 4$) when $g_2 = 0$ (the 'other' countries), while ($\beta_i + \beta'_i$) gives the effects for the least developed countries (developed countries). The Chow-test is then a joint test on the null hypothesis that the interacted coefficients $g_2\beta_i$ are zero.

We perform the Chow-tests for specification (4) in Table 2.1. We find that, when g_2 is a dummy variable indicating whether or not a country belongs to the group of *least developed countries*, the null hypothesis that the interacted coefficients $g_2\beta_i$ are zero cannot be rejected. The F-statistic is 0.19. In other words, we cannot reject the hypothesis that coefficients for the least developed and the other countries are by and large alike. That is, the least developed countries do not appear to constitute a case of their own. This evidence does not indicate that the relation between FDI inflows and, e.g., human capital and institutional quality only exists above a certain threshold, which the least developed countries do not meet (an argument often made in development economics). However, the number of observations for the least developed countries is small, so these conclusions are tentative. Still, based on the results, it seems justified to estimate a pooled model in this case. If, on the other hand, we use g_2 to indicate whether a country is a *most developed country or not*, the F-statistic for the Chow-test is 2.43, in which case the null hypothesis that the $g_2\beta_i$ are zero is rejected at the 5 per-cent level. This suggests that the model does not equally apply to both the most developed and other countries.[32] Columns (8) and (9) in Table 2.1 give the results for specification (4) estimated separately for the most developed countries and the other countries in the sample. The

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[31] The percentage impact of a dummy variable is calculated as $(e^{\beta_k} - 1) * 100\%$.

[32] If one applies a 2.5 per-cent level, the null hypothesis cannot be rejected.

most evident difference between the results for the two samples is with respect to the effect of human capital: the effect is negative and statistically significant in the developed-country sample. Still, we believe this is very much the result of the data. In the developed-country sample, countries like, e.g., Norway and New Zealand have a high score on schooling quality (*QL*) but attract lower levels of FDI.[33] At the same time, the U.S., Germany and Luxembourg attract high levels of inward FDI but have a relatively low score on the *QL*-indicator. However, the variance in *QL* within the developed-country sample is relatively small: the standard deviation of *QL* for the developed countries is only approximately one-third of that for the entire sample (against 70 per cent in the case of FDI inflows).

In order to get a sense of the *relative* importance of the explanatory variables in specification (4) in Table 2.1 in explaining FDI, we calculate standardised coefficients, also known as beta coefficients. A beta coefficient is defined as the product of the estimated coefficient of an independent variable and the variable's standard deviation, divided by the standard deviation of the dependent variable (Wooldridge, 2003, Helpman et al., 2004). It reflects how much of the average variation in the dependent variable is caused by variation in the independent variable. By looking at the contribution of each of the independent variables to the average variation in FDI we can assess their relative importance. The statistics needed to calculate the beta coefficients are given in the Appendix 2A.

Table 2.2 gives the results. We present the beta coefficients for all variables in specification (4), including the ones that are not statistically significant. Statistical significance merely indicates that, taking into account the standard error of the estimate, we cannot confidently rule out the possibility that a coefficient is zero. Nevertheless, the (size of the) estimate is still best linear unbiased (BLUE).[34] The results in Table 2.2 suggest that market size accounts for most of the variation in FDI by far. The beta coefficients indicate that a one standard deviation increase in GDP raises FDI inflows by almost two thirds of a standard deviation. This finding is consistent with previous findings in the FDI literature (e.g., Markusen, 2002). The variation in FDI inflows accounted for by the average variation in institutional quality is 27 per cent. The variation in human capital explains 10 per cent of the variation in FDI inflows when institutional quality and geography are controlled for. The geographic factors account for 0.03 (climate) and 0.09 (landlocked dummy) per cent of the variation in FDI inflows.

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[33] The relative remoteness of these countries may explain why they attract lower levels of FDI within the group of developed countries (see, e.g., Redding and Venables, 2004, on distance-weighted GDP).
[34] Ziliak and McCloskey (2004), e.g., warn that economists put too much emphasis on statistical significance. They argue that the (economic) importance of a variable depends on the size of its coefficient, not its statistical significance.

Table 2.2. Beta coefficients total FDI

	Specification (4) in Table 2.1
Log GDP	0.62
Log Human capital	0.10
Institutional quality	0.27
Climate	0.03
Landlocked	0.09

2.5. Human capital and high-tech FDI

In this section we investigate the importance of human capital in attracting high-tech FDI. Due to limited data availability the results are based on a small group of countries.[35]

Table 2.3 gives the estimation results. The first three columns in Table 2.3 present the results regarding FDI inflows in machinery and equipment. Specifications (4) – (6) present the results for FDI inflows in electrical and electronic equipment.

The results in columns (1) – (3) indicate that neither human capital nor institutional quality has a significant effect on FDI in machinery and equipment.[36] This type of FDI is explained primarily by GDP. On the other hand, human capital is important for FDI inflows in electrical and electronic equipment. FDI inflows in electrical and electronic equipment increase with both human capital and institutional quality in the host country (columns (4) and (5)). The effect of human capital is statistically significant at the 10 per cent level. Controlling for the effect of human capital and institutional quality simultaneously (column (6)), neither variable is statistically significant. Still, human capital explains a larger share of the variation in FDI inflows in electrical and electronic equipment. This is illustrated in Table 2.4.

[35] In the data set a lot of observations on inflows in high-tech sectors are recorded as missing. We attempted to estimate a sample selection model to properly deal with zero flows. The basic idea of the sample selection model is that zero flows of the dependent variable, here FDI, are not random. The sample selection model has two stages. The first stage models a binary choice problem, which determines whether or not we will observe investment. The choice to invest or not is dependent on some underlying (latent) variable – let's say profitability. Firms will only decide to enter a market when the action is sufficiently profitable. Next, the selection model estimates the expected value of FDI, given that FDI is observed. Estimating FDI without first estimating whether FDI is observed can lead to a sample selection bias (cf. Heckman, 1979). OLS regression coefficients for the observed sample of non-zero FDI would then underestimate the true effect on FDI. Intuitively we can say that the sample selection model takes into account that FDI has to be profitable in the first place. Variables like GDP, human capital and institutional quality for instance have an effect on this. It follows that the impact of these variables is larger than would appear from OLS on the observed sample. Unfortunately, the number of observations in our data set proved too small to estimate a sample selection model.

[36] Checking the samples used to estimate specifications including inflation and institutional quality in Tables 2.3 and 2.7 and 2.8 below, it is not the case that only a few highly developed (homogeneous) countries are left.

Table 2.3. The impact of human capital on high-tech FDI

	Machinery & equipment			Electrical & electronic equipment		
	(1)	(2)	(3)	(4)	(5)	(6)
Log GDP	1.45***	1.44***	1.44***	0.98***	0.94***	0.97***
	(7.87)	(7.79)	(7.63)	(5.98)	(6.44)	(6.53)
Log Human capital	0.11		0.10	1.98*		1.70
	(0.08)		(0.06)	(2.11)		(1.18)
Institutional quality		–0.01	–0.04		0.72	0.15
		(0.03)	(0.08)		(1.49)	(0.20)
Constant	–34.03***	–33.35***	–33.72***	–28.34***	–20.14***	–27.19***
	(5.26)	(6.87)	(4.47)	(5.10)	(4.90)	(4.98)
Adjusted R^2	0.67	0.66	0.65	0.48	0.44	0.45
Observations	32	31	31	19	19	19

Robust (absolute) *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

The first column in Table 2.4 presents the beta coefficients for specification (6) in Table 2.3. Human capital explains approximately thirty per cent of the total variation in FDI in electrical and electronic equipment. The contribution of institutional quality is small. In the specification excluding institutional quality human capital is estimated to account for one third of the variation in FDI in electrical and electronic equipment.[37] The beta coefficients on human capital in Table 2.4 are larger than the one in Table 2.2 (total FDI), which suggests that the quality of human capital is relatively more important for FDI in electrical and electronic equipment than total FDI. This result can be attributed primarily to the magnitude of the effect of human capital on FDI in electrical and electronic equipment. The results in Table 2.3 indicate that FDI inflows in this sector are highly elastic with respect to human capital: a one per cent increase in the quality of human capital increases FDI inflows more than proportionally. Similar to total FDI, GDP accounts for most of the variation in FDI in electrical and electronic equipment as well.

Table 2.4. Beta-coefficients high-tech FDI

	Spec. (6) in Table 2.3	Spec. (4) Table 2.3
Log GDP	0.66	0.66
Log Human capital	0.29	0.33
Institutional quality	0.06	

[37] This specification has in fact the highest explanatory power.

2.6. High-tech FDI and type of skills

In this section we investigate whether technical skills as opposed to managerial skills are more important for attracting high-tech FDI. First, we examine the impact of different types of skills on total FDI inflows.[38] The results are given in Table 2.5.[39] In specification (1) we regress FDI inflows on the level of GDP and the types of skills; next we regress FDI inflows on the level of GDP, different types of skills and institutional quality; in the last specifications we add the geographic characteristics.[40]

Table 2.5. Type of skills – total FDI

	(1)	(2)	(3)
Log GDP	0.79***	0.60***	0.63***
	(10.60)	(6.64)	(6.99)
Log Enrolment science	0.29	0.13	0.15
	(1.28)	(0.64)	(0.77)
Log Enrolment engineering	0.43***	0.30**	0.21
	(2.81)	(2.13)	(1.34)
Log Enrolment social science	0.89	0.83*	0.88**
	(1.57)	(1.96)	(2.09)
Institutional quality		0.77***	0.55**
		(3.17)	(2.62)
Climate			0.58*
			(1.86)
Landlocked			0.54
			(1.43)
Constant	–17.01***	–11.92***	–12.84***
	(8.09)	(6.21)	(6.17)
Adjusted R^2	0.73	0.79	0.80
Observations	73	73	73

Robust (absolute) *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

[38] The enrolment and *QL* samples differ. Hence, so does the average variation of FDI (see the descriptive statistics in Appendix 2A).

[39] Similar to Section 2.4 we performed Chow-tests to see whether the impacts from the independent variables are the same for different sub-groups. We once again performed two tests: one in which the estimation coefficients for the least developed countries are examined and one in which we do the same for the most developed countries. In both cases, we find that the null hypothesis that the interacted coefficients $g_2\beta_i$ are zero cannot be rejected. *F*-statistics are 0.97 and 1.44. Thus, the least developed or developed countries do not appear to constitute a case of their own. As a result, we estimate a pooled model to investigate the effect of the type of skills on total FDI inflows.

[40] We also ran regressions with inflation. But its coefficient was statistically insignificant in every specification. We omit these results here. They are available on request.

Table 2.5 indicates that the enrolment variables are all positive. Yet, only enrolment in social sciences, business and law is statistically significant when institutional quality and geography are controlled for. These results suggest that managerial skills in the host country are important for attracting total FDI. The effect of technical skills (measured by enrolment in science and in engineering, manufacturing and construction) cannot be verified at conventional significance levels. Similar to the regressions with human capital, institutional quality again has a positive and statistically significant effect on FDI inflows in the sample with the enrolment variables. The effect of climate (third column) is positive and statistically significant at the 10 per cent level. The landlocked dummy once again has a positive coefficient, against expectation. It is not significant statistically.

Table 2.6 gives the beta coefficients for specification (3) in Table 2.5. The results indicate that managerial skills account for thirteen per cent of the variation in FDI. Technical skills together account for eleven per cent of the variation in total FDI, although this effect cannot be verified statistically as explained above. Although we cannot directly compare beta coefficients across Table 2.2 and Table 2.6 (see the descriptive statistics in Appendix 2A), GDP, institutional quality and the landlocked variable account for rather similar shares of the variation in FDI as in the regression with human capital. The results once again suggest that market size accounts for about sixty per cent of the standard deviation in FDI inflows. The variation in FDI inflows accounted for by the average variation in institutional quality and the landlocked dummy is 23 and 9 per cent, respectively. The relative importance of the climate variable is somewhat larger in the regressions with the type of skills than with the human capital sample.[41]

Table 2.7 presents the results for the effect of the different types of skills on FDI inflows in machinery and equipment. Column (1) gives the results for technical skills.

Table 2.6. Beta coefficients total FDI

	Spec. (3) Table 2.5
Log GDP	0.61
Log Enrolment science	0.04
Log Enrolment engineering	0.07
Log Enrolment social science	0.13
Institutional quality	0.23
Climate	0.12
Landlocked	0.09

[41] This is probably the result of lower correlation between the climate variable and the enrolment variables. See Appendix 2A.

Table 2.7. High-tech FDI and type of skills – machinery and equipment

	(1)	(2)	(3)
Log GDP	1.29***	1.37***	1.40***
	(5.58)	(7.23)	(6.96)
Log Enrolment science	0.01		
	(0.02)		
Log Enrolment engineering	1.05		
	(1.33)		
Log Enrolment social science		–0.36	
		(0.31)	
Institutional quality			–0.23
			(0.44)
Constant	–32.30***	–30.15***	–31.97***
	(7.09)	(4.94)	(6.38)
Adjusted R^2	0.65	0.63	0.64
Observations	26	26	26

Robust (absolute) *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Enrolment in engineering, manufacturing and construction is estimated to have a positive effect on FDI in machinery and equipment but this effect is not significant statistically.The effect of enrolment in science is highly uncertain. Columns (2) and (3) indicate that enrolment in social sciences, business and law and institutional quality play no significant role in attracting FDI in machinery and equipment. The *t*-statistics of these variables are very low. Also, the share of total variation in FDI inflows in machinery and equipment specifications explained by these specifications is less than the specification with technical (engineering) skills. Specifications (2) and (3) are explained by GDP primarily. Thus, the results in Table 2.7 suggest that in the case of machinery and equipment *technical*, i.e. engineering, skills matter most for attracting FDI.

Table 2.8 presents the results for FDI in electrical and electronic equipment. Specification (1) once again gives the results for technical skills. Both coefficients are positive and the coefficient on enrolment in science is statistically significant at the 10 per cent level. Enrolment in social sciences, business and law once again has no significant effect (specification (2)). Specification (3) suggests that institutional quality also has a positive effect on FDI in electrical and electronic equipment. The coefficient is nearly significant statistically at 10%. Specification (4) combines technical skills and institutional quality. Enrolment in engineering, manufacturing and construction, and institutional quality in particular now have but a statistically weak effect on FDI in electrical and electronic equipment.

Table 2.8. High-tech FDI and type of skills – electrical & electronic equipment

	(1)	(2)	(3)	(4)
Log GDP	0.46^{*}	0.89^{***}	0.77^{***}	0.50^{*}
	(1.94)	(6.71)	(6.02)	(1.99)
Log Enrolment science	1.24^{*}			0.90
	(1.86)			(1.12)
Log Enrolment engineering	0.61			0.54
	(1.01)			(0.79)
Log Enrolment social science		0.59		
		(0.48)		
Institutional quality			0.71	0.38
			(1.53)	(0.62)
Constant	-11.64^{**}	-20.49^{***}	-16.09^{***}	-12.18^{**}
	(2.26)	(5.24)	(5.45)	(2.31)
Adjusted R^2	0.46	0.39	0.47	0.44
Observations	17	17	17	17

Robust (absolute) *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2.9 presents the beta coefficients for specification (1) in Table 2.7 and specification (4) in Table 2.8. The beta coefficients on technical skills measured by enrolment in science and in engineering, manufacturing and construction in Table 2.9 are larger than those for total FDI (in Table 2.6). This suggests that technical skills are relatively more important for attracting FDI in high-tech sectors than total FDI.

Table 2.9. Beta-coefficients high-tech FDI

	Machinery & equipment	Electrical & electronic equipment
	Spec. (1) in Table 2.7	Spec. (4) in Table 2.8
Log GDP	0.77	0.37
Log Enrolment science	0.00	0.32
Log Enrolment engineering	0.18	0.14
Institutional quality		0.16

2.7. Conclusion

This chapter has empirically examined the role of human capital, inflation, institutional quality and geographic characteristics in attracting FDI inflows: to what extent do these factors explain the variation in FDI inflows across host countries? We find that institutional quality is an important determinant of total FDI inflows across host countries. Institutional quality explains up to 27 per cent of the average variation in total FDI. The effect of institutional quality is robust across different specifications. Inflation, which we have used as an alternative, less encompassing, measure of macro (in)stability than institutional quality, is much less robust. Human capital and geography each explain about 10 per cent of the total variation in total FDI inflows, but the effects are not robust when the effects of human capital, institutional quality or inflation, and geography are simultaneously controlled for. Still, the single most important determinant of total FDI is GDP. GDP has a statistically significant effect in all regressions and explains over 60 per cent of the average variation in total FDI inflows across countries.

We extend the analysis of human capital to FDI in technology-intensive sectors. Is human capital more conducive to attracting FDI in technology-intensive sectors than total FDI? High-tech FDI is proxied by FDI in machinery and equipment and electrical and electronic equipment. The proviso concerning the number of observations applies. Having said this, the quality of human capital appears to be relatively more important for FDI in electrical and electronic equipment than for total FDI. Our results indicate that FDI inflows in this sector are highly elastic with respect to human capital: a one per cent increase in the quality of human capital increases FDI inflows more than proportionally. Human capital is also more important than institutional quality in explaining FDI in electrical and electronic equipment. The latter is less important in FDI in electrical and electronic equipment than in total FDI. In fact, the effect of institutional quality on FDI in electrical and electronic equipment is highly insignificant when human capital is included. Human capital and institutional quality have no significant effect on FDI in machinery and equipment. This type of FDI is explained almost entirely by GDP.

We also investigated whether attracting FDI in machinery and equipment and electrical and electronic equipment requires technical rather than managerial skills. Our conclusion is affirmative: technical skills (measured by enrolment in science and in engineering, manufacturing and construction) are more important for attracting FDI in machinery and equipment and electrical and electronic equipment than managerial skills. The latter (measured by enrolment in social sciences, business and law) have no significant effect on FDI in machinery and equipment nor electrical and electronic equipment, whilst having a statistically significant positive impact on total FDI inflows. The statistical significance of institutional quality on FDI in machinery and equipment and electrical and electronic equipment is very low in specifications that control for technical skills as well.

This chapter demonstrates *what* factors can potentially explain the variation in FDI inflows across host countries. Yet, the approach is rather eclectic: the stylised facts in Chapter 1 indicate that FDI flows mainly towards developed countries and human capital, inflation, institutional quality and geographic characteristics like being located in temperate ecozones are characteristics of developed countries. The selection of explanatory variables is, however, not tied back to a specific theoretical model of location selection by firms. This can lead to omitted variable bias in the empirical specification (see also, e.g., Chakrabarti, 2001). General-equilibrium models of FDI exist for bilateral FDI. These models *explain* how FDI comes about and specify long-term factors that determine the magnitude of FDI between countries based on a microeconomic theory of firm decision making. The empirical analysis in Part II of this study is based on bilateral FDI. The unit of examination is FDI from parent country i directed toward host j. Chapter 3 motivates and describes the research approach for the analysis in Part II.

Appendix 2A – Data

Table 2A.1 gives the descriptive statistics for the data used in the estimations with human capital.

Table 2A.1 – Descriptive statistics regressions with human capital

	Mean	Std. Dev.	Maximum	Minimum	Observations
Log total FDI	7.35	2.19	11.89	1.99	69
Log FDI machinery	4.21	3.09	8.28	–3.22	29
Log FDI electrical	5.70	1.96	9.37	1.51	18
Log GDP	24.76	2.02	29.87	20.66	69
Log Human capital	3.76	0.31	4.21	2.90	69
Log Inflation	1.67	0.93	4.02	–0.41	69
Institutional quality	0.46	0.90	1.91	–1.17	69
Landlocked	0.13	0.34	1	0	69
Climate	0.47	0.45	1	0	69

Table 2A.2 gives the descriptive statistics for the data used in the estimations with enrolment.

Table 2A.2 – Descriptive statistics regressions with enrolment

	Mean	Std. Dev.	Maximum	Minimum	Observations
Log total FDI	6.75	2.24	11.48	0.44	73
Log FDI machinery	3.51	3.16	8.10	–3.22	22
Log FDI electrical	4.61	2.04	7.44	0.36	14
Log GDP	24.16	2.16	29.12	20.37	73
Log Enrol. science	2.01	0.63	2.97	–0.26	73
Log Enrol. engineering	2.35	0.77	3.58	–0.09	73
Log Enrol. social science	3.47	0.33	4.05	2.41	73
Institutional quality	0.32	0.95	1.91	–1.42	73
Climate	0.51	0.45	1	0	73
Landlocked	0.18	0.39	1	0	73

Tables 2A.3 and 2A.4 present correlation matrices.

Table 2A.3 – Correlation matrix for regressions total FDI with human capital (*N*=69)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Log FDI							
2. Log GDP	0.79						
3. Log Human capital	0.53	0.38					
4. Log Inflation	–0.44	–0.33	–0.43				
5. Institutional quality	0.69	0.53	0.61	–0.67			
6. Landlocked	–0.05	–0.27	0.03	–0.02	0.07		
7. Climate	0.61	0.51	0.68	–0.42	0.75	0.00	

Table 2A.4 – Correlation matrix for regressions total FDI with enrolment (*N*=73)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Log FDI								
2. Log GDP	0.84							
3. Log Enrolment science	0.23	0.22						
4. Log Enrolment engineering	0.42	0.37	–0.17					
5. Log enrolment social science	0.18	0.06	0.04	0.02				
6. Institutional quality	0.75	0.64	0.24	0.32	0.07			
7. Landlocked	–0.07	–0.23	–0.07	0.08	–0.11	0.03		
8. Climate	0.65	0.56	0.11	0.37	0.07	0.70	–0.11	

3

The Literature on Bilateral FDI

3.1. Introduction

Chapter 2 served as a first introductory empirical analysis in the investigation into the sources of attraction for FDI using data on FDI *inflows*. The analysis was not based on an explicit theoretical framework. General-equilibrium models of FDI do exist for *bilateral* FDI. The analysis in Part II of this study is therefore based on bilateral FDI. In this chapter we motivate and describe the research approach for the empirical analysis in Part II. The chapter is organised as follows. We begin by presenting the main theoretical contributions in the literature on bilateral FDI. Section 3.2 briefly presents Dunning's OLI-paradigm of international production. Sections 3.3 and 3.4 describe the knowledge-capital model and the proximity-concentration trade-off. This is followed by a critical review of these two models and the empirical work related to them in Section 3.5. Section 3.6 presents the extensions and contributions of Part II and the outline of the empirical analysis in Chapters 4–6.

3.2. Dunning's OLI-framework

The eclectic paradigm of international production by John Dunning (e.g., 1980, 1988 and 2001) offers a general, but very useful, conceptual framework to explain FDI. Rather than offering a theory of the multinational enterprise, the eclectic paradigm points to "a methodology and to a generic set of variables which contain the ingredients necessary for any satisfactory explanation of particular types of foreign (…) activity" (Dunning, 2001, p. 177). The eclectic paradigm explains international production undertaken by MNEs and financed though FDI by a set of three variables: ownership (O) advantages, location (L) advantages and internalisation (I) advantages.[42]

Ownership-specific advantages give firms a competitive advantage over local competitors in supplying any particular market or set of markets. These advantages stem from the firms' privileged ownership of assets. Assets may be created by the firm itself (e.g., types of technology and organisational skills), but the firm can also purchase assets created elsewhere. In doing so, the firm obtains proprietary right of use over existing assets. While in the OLI-framework FDI is, in the first instance, thought of as a means to *exploit* ownership-specific advantages, FDI can also be a vehicle to *create* or *augment* existing advantages.[43] According to Dunning (2001) this is pertinent particularly in the sourcing of technological assets. Ownership-specific advantages may then also consist of the ability of MNEs to access new assets and co-ordinate these assets with existing assets across national boundaries.

Ownership-specific advantages explain *which* firms will supply a particular foreign market. Internalisation advantages explain *why* firms choose to use these assets themselves (i.e. through owned subsidiaries) to exploit foreign markets rather than to sell the assets or the right of use to some foreign-based enterprise.[44] Such internalisation advantages stem from market failure connected with the assets (difficulty to (fully) appropriate rents and/or high transaction costs).

Third, firms must have a reason to want to locate production abroad. Location-specific characteristics of the host country make it more profitable to locate activities abroad rather than in the home country.

The general equilibrium models of FDI discussed in this chapter build on the OLI-idea that firms possess ownership-specific advantages and examine the external factors that determine (the pattern of) FDI.

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[42] The exact form and significance of each of the OLI parameters will vary across industries, countries and firms.

[43] This is reflected in the increasing importance of mergers and acquisitions and strategic alliances since the second half of the 1990s (Dunning, 2001).

[44] Dunning acknowledges that internalisation may also constitute ownership advantages of its own. Transaction ownership advantages reflect the capacity of MNE hierarchies vis-à-vis external markets to capture transactional benefits arising from the common governance of a network of assets (Dunning, 1988). Nevertheless, he notes, "the ability of a firm to benefit from [internalisation] must be related to the assets which it possesses *prior* to the act of internalisation" (Dunning, 2001, p. 175).

3.3. The knowledge-capital model

The knowledge-capital model provides the most articulate general equilibrium model of MNE with proper microeconomic foundations (Markusen et al., 1996, Markusen, 1997 and 2002).[45] The model integrates two motivations for FDI in a single general equilibrium model of MNEs: to access markets in the face of trade frictions (horizontal FDI) and to exploit factor-cost differentials due to different relative factor supplies (vertical FDI). The model typically has two countries, two factors of production and two sectors. Both sectors produce homogeneous goods, *Y* and *X*. *Y* is produced with constant returns to scale by perfectly competitive firms. The *X* sector is imperfectly competitive, with Cournot firms, free entry and exit and increasing returns to scale. There are scale economies at the plant level and at the firm level, the latter arising from fixed costs associated with the knowledge asset. The *X* sector is one in which (entering) firms choose their organisational structure, i.e., horizontal or vertical multinationals or national firms.

Scale economies at the firm level give rise to horizontal, type-h, firms. Type-h firms have production plants in several markets. The model assumes that knowledge assets have a joint-input or public good character: once created, the knowledge assets can be supplied to foreign production facilities at relatively low additional costs. Whether firms decide to service foreign markets through exports (i.e. be a type-d or national firms) or through an additional local plant (type-h firms) depends on the plant-level scale economies relative to trade costs. Foreign markets should be large for firms to be able to exploit scale economies at the plant level.

Furthermore, the knowledge-capital model assumes that production can be fragmented from the location of the knowledge assets (typically associated with the headquarters). This motivates firms to locate a single production plant and headquarters in different countries when factor endowments differ between countries. These properties give rise to vertical, or type-v, MNEs. The knowledge-capital model makes a number of assumptions regarding factor intensities. First, the activities associated with headquarters, i.e. the knowledge-based and knowledge-generating activities, and the managing and coordinating of plants are skilled-labour intensive. Therefore, production plants are less skilled-labour intensive than an integrated firm with headquarters and a plant in the same location.[46] Next, since horizontal firms require additional skilled labour in the home

[45] The knowledge-capital model and the proximity-concentration model (see Section 3.4 below) draw heavily on theoretical advances in models of international trade in the late 1970s, i.e. the incorporation of imperfect competition and economies of scale in formal models of trade (see, e.g., Krugman, 1979, 1980).

[46] Multinational production is considered unskilled-labour intensive *relative* to headquarter activities. Considered in its own right, multinational production will in most cases be quite advanced. Empirical evidence suggests that multinationals are an important source of superior knowledge or technology: multinationals undertake a major part of the world's private R&D efforts and produce, own, and control most of the world's advanced technology (Blomström and Kokko, 2003). In the knowledge-capital model this is reflected by the assumption that a plant alone (no headquarters) is more skilled-labour intensive than firms in the composite *Y* sector.

country so as to manage and coordinate the second plant, horizontal firms are assumed to be more skilled-labour intensive than either vertical MNEs or national firms. A foreign plant (of both horizontal and vertical firms) is assumed to be more skilled-labour intensive than national firms. The added skilled labour comes from the host country and reflects that technology transfer is not costless. That is, some additional skilled labour is needed in the host country so as to implement a blueprint in the foreign plant.

The knowledge-capital model predicts that type-h firms dominate when markets in both countries are large and countries are similar in relative skill endowments. Economies of scale explain the need for size in both markets. The reason for skill similarity in this type of FDI is that if countries are dissimilar it becomes more profitable to concentrate production in the skilled-labour scarce country and headquarters in the skill abundant country (vertical FDI). Moreover, when trade costs are very high, firms will seek proximity to markets and avoid trade costs involved in exporting. Type-v firms dominate when countries differ in size and relative skill endowments. In particular, if country *i* is small and relatively skilled-labour abundant, while country *j* is large and relatively skilled-labour scarce, this motivates firms to locate headquarters in country *i* and a single production plant in country *j*. Type-v firms may or may not export back to the parent country depending on trade costs in the parent country. High investment costs in the host country reduce both horizontal and vertical FDI.

Carr et al. (2001) (henceforth CMM) are the first to test the knowledge-capital model empirically. A problem is how to translate the general equilibrium theory to an empirical specification (Blonigen, 2005). The knowledge-capital model is complex (many dimensions and many inequalities in addition to a few equalities) and does not have closed-form solutions. The predictions are generated by numerically solving the model (simulation). From the numerical simulations CMM derive the following equation to estimate the knowledge-capital model:

$$\begin{aligned} FDI_{ij} &= \beta_0 + \beta_1 SUMGDP_{ij} + \beta_2 (GDPDIFF_{ij})^2 + \beta_3 SKDIFF_{ij} + \\ &\beta_4 (GDPDIFF_{ij} \times SKDIFF_{ij}) + \beta_5 INVC_j + \beta_6 TC_j + \beta_7 (TC_j \times SKDIFF_{ij}^{\;2}) + \\ &\beta_8 TC_i + \beta_9 DIST_{ij} + \varepsilon_{ij}, \end{aligned} \tag{3.1}$$

where FDI_{ij} denotes FDI from parent *i* to host *j*. $SUMGDP_{ij}$ is the sum of real GDP in both countries and captures the horizontal motives for FDI. Its coefficient is expected to be positive. $(GDPDIFF_{ij})^2$ is the squared difference in real GDP between the parent country and the host country and is expected to have a negative influence, since theory suggests an inverted U-shaped relation to differences in country size, with FDI attaining a maximum when differences in GDP between countries are zero. The variables

$SKDIFF_{ij}$ and ($GDPDIFF_{ij} \times SKDIFF_{ij}$) are the key variables that distinguish vertical FDI within the knowledge-capital model. $SKDIFF_{ij}$ measures the skill abundance in the parent country relative to the host country. Its coefficient is expected to be positive because the headquarters of firms are expected to be located in the skilled-labour-abundant country. The interaction term ($GDPDIFF_{ij} \times SKDIFF_{ij}$) is expected to have a negative coefficient. Relative skill abundance in the parent country is reinforced if the parent country is small ($GDPDIFF$<0) and relatively skill abundant compared to the host country ($SKDIFF_{ij}$>0). The fifth and sixth variable, $INVC_j$ and TC_j, respectively, measure the cost of investing in and exporting to the host country j. The coefficient of $INVC_j$ is expected to be negative; the cost of investing in the host country is likely to reduce FDI. The coefficient of TC_j is expected to be positive as high trade costs will induce substitution of horizontal FDI for exports to the host market. The positive effect of TC_j on FDI is reduced if the two countries are very dissimilar in relative endowments. If countries are dissimilar, horizontal FDI will be less important. Therefore the coefficient of ($TC_j \times SKDIFF_{ij}^2$) is expected to be negative.[47] TC_i is a measure of the cost of exporting to the parent country, and is expected to negatively influence FDI_{ij} as trade costs diminish the incentive to locate plants abroad and export back to the parent country. Finally, geographical distance $DIST_{ij}$ is added to the relation. According to CMM the sign of this variable is ambiguous in theory as distance can be an element in export costs or investment and monitoring costs. In the former case, one would expect the coefficient to be positive as distance encourages the substitution of exports by FDI. In the latter case, the coefficient will be negative as investment and monitoring costs act to reduce FDI.[48]

CMM use data on sales of foreign affiliates of American MNEs and sales of U.S. affiliates of foreign MNEs to estimate the knowledge-capital model. The data are from the U.S. Bureau of Economic Analysis (U.S. Department of Commerce). CMM conclude that the knowledge-capital model explains much of the variation in affiliate sales. The model has a strong statistical fit and coefficients by and large all have the expected sign.[49] The estimates yield strong statistical significance for the variables $SUMGDP_{ij}$, $(GDPDIFF_{ij})^2$, $SKDIFF_{ij}$ and ($GDPDIFF_{ij} \times SKDIFF_{ij}$).[50] In their own words (p. 704), "the evidence suggests more weakly that affiliate activity depends on investment costs and trade costs in the hypothesised directions". We have reproduced the results from CMM Tables 3 and 4 in Table 3.1.

[47] However, according to CMM, this is not a theoretically sharp hypothesis.
[48] See Chapter 6 below for an elaborate analysis of the (relative) impact of distance on FDI and trade.
[49] Only the interaction variable $TC_j \times SKDIFF_{ij}^2$ is not significant in any of their regressions.
[50] In specifications with fixed effects the role of skill differences becomes smaller both in terms of size and statistical significance (see Table 3.1). CMM: "Most of the countries in the sample are less skilled-labour-abundant than the U.S. It may be that the country dummies capture some of this effect that should be correctly attributed to endowment differences" (Carr et al., 2001, p. 704).

Table 3.1. Estimating the knowledge-capital model: results from Carr et al. (2001)

	Basic results (CMM Table 3)			Fixed effects estimation (CMM Table 4)		
	OLS	WLS	Tobit [a]	OLS	WLS	Tobit [a]
$SUMGDP_{ij}$	10.80***	13.92***	15.04***	13.41***	13.72***	16.57***
	(7.01)	(9.80)	(10.27)	(12.81)	(13.62)	(17.44)
$(GDPDIFF_{ij})^2$	–0.001***	–0.001***	–0.001***	–0.001***	–0.001***	–0.001***
	(6.89)	(8.94)	(5.89)	(8.07)	(9.81)	(8.01)
$SKDIFF_{ij}$	33,743***	31,044***	61,700***	20,084	15,042	29,366**
	(3.77)	(4.01)	(7.28)	(1.57)	(1.34)	(2.34)
$GDPDIFF_{ij} \times SKDIFF_{ij}$	–6.34**	–4.27**	–10.20***	–5.91**	–4.44**	–7.71***
	(2.62)	(2.12)	(4.34)	(2.42)	(2.09)	(3.22)
$INVC_j$	–516.6***	–455.6***	–387.6***	–198.8	–173.2	–41.3
	(3.79)	(3.92)	(2.82)	(1.49)	(1.52)	(0.32)
TC_j	119.2	190.6**	156.2	74.9	69.4	144.0*
	(1.16)	(2.20)	(1.51)	(0.96)	(1.02)	(1.93)
$TC_j \times SKDIFF_{ij}^2$	605.2	–569.9	–1,264	–388.2	–811.6	–2,273
	(0.36)	(0.41)	(0.75)	(0.24)	(0.57)	(1.49)
TC_i	–93.7	–93.3	–122.0	–87.7	–75.5	–112.6**
	(0.99)	(1.14)	(1.46)	(1.63)	(1.60)	(2.43)
$DIST_{ij}$	–1.82***	–1.34***	–1.48***	–1.08***	–0.87***	–0.77***
	(7.75)	(6.63)	(6.47)	(5.45)	(4.95)	(4.28)
Constant	16,630	–5,381	–23,282	–22,492**	–24,552**	–53,341***
	(1.08)	(0.42)	(1.61)	(2.00)	(2.57)	(5.24)
Adjusted R^2	0.47	0.60		0.83	0.87	
Observations	509	509	628	509	509	628

Absolute *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

[a] Adding an additional 119 cases for which observations are missing but assumed to be zeros.

Source: reproduced from Carr et al. (2001), their Tables 3 and 4.

Markusen and Maskus (2002) compare the knowledge-capital model against a restricted horizontal and a restricted vertical version, using the U.S. data on affiliate sales as Carr et al. (2001). The prediction that FDI is important between countries that are similar in both size and skill endowments, finds the most confirmation in the data.An independent vertical model provides a poor characterisation of the overall pattern of world FDI.[51]The coefficients have the expected sign and are statistically significant. Yet,

[51] Nevertheless, Carr et al. (2003) state that the weak support in Markusen and Maskus (2002) for an independent vertical model may be partly the result of the data. The U.S. is relatively large whereas the vertical model predicts FDI when the parent is small and skilled-labour abundant. Hence, there is not much ‘power to

the model has much lower explanatory power than the horizontal model and the knowledge-capital model. The results provide strong support for the knowledge-capital model, but the results do not permit a distinction between the knowledge-capital and horizontal models. Markusen (2002) concludes that he results in Markusen and Maskus (2002) are consistent with the stylised fact that the overwhelming share of world investments is between high-income, developed countries.

3.4. The proximity-concentration trade-off

To serve foreign markets, firms can decide either to export or to service the foreign markets locally by setting up a subsidiary through horizontal FDI. Brainard (1997) models the production-location decision of firms as a trade-off between achieving proximity to local markets so as to circumvent transport costs and trade barriers, and concentrating production so as to exploit economies of scale. This is referred to as the proximity-concentration trade-off.

The model in Brainard (1997) assumes two factors, two countries, and two sectors. One sector produces a homogeneous good, using constant returns to scale, the other sector produces differentiated goods with increasing returns to scale. Scale economies at the firm level arise due to the existence of firm-specific fixed costs at the corporate level $R(w)$, such as R&D. There are also scale economies at the plant level due to fixed costs in production, $F(w)$. Both fixed costs are a function of the local wage in market i (w_i). Assuming Chamberlinian monopolistic competition in the differentiated goods sector, firms in both markets simultaneously choose their plant configuration and prices, taking their competitors' configuration and prices as given. Equilibrium in this sector is determined by pricing equations (marginal revenue equals marginal cost) and free-entry conditions (profits are zero). The wage rate w equals the value marginal product of labour in the production of the homogeneous good. Assuming symmetry in factor endowments, wages will be equal across the two countries. In the absence of factor price differences, firms choose between producing overseas and exporting by comparing the additional variable cost of exporting against the additional fixed cost of opening a new plant abroad.[52] Exporting is assumed to incur per-unit transport costs and costs associated with trade barriers. For some amount q produced in market i, the amount that survives shipment to the foreign market j decreases in the distance between the markets, D, and the transport costs, T, i.e. $q_{ij}e^{-(T+D)}$.

the test' to distinguish between the horizontal and the knowledge-capital model when the U.S. is parent (Carr et al., 2003). Braconier et al. (2002) add more power to the test by adding Swedish data to the Markusen and Maskus data set. This entails adding more observations in which the parent is small and skilled-labour abundant. They find more support for a vertical model.

[52] The proximity-concentration model is essentially a model of horizontal FDI.

On the demand side, Brainard assumes homothetic preferences across the two aggregated goods. Demand for the differentiated good is characterised by a constant elasticity of substitution σ.

The equilibrium location decision depends on the sign of the following expression:

$$\frac{F(w)}{R(w)} - \frac{1-e^{(T+D)(1-\sigma)}}{2e^{(T+D)(1-\sigma)}} \tag{3.2}$$

There are three possibilities:

- Expression (3.2) < 0. This holds if transport costs and trade barriers are high and fixed plant costs are small relative to fixed corporate costs. In the associated equilibrium, all firms have plants in both markets (*multinational equilibrium*);
- Expression (3.2) > 0. This holds if transport costs and trade barriers are low and fixed plant costs are high relative to fixed corporate costs. All firms then have a single plant located in the same market as their corporate headquarters. They export to the foreign market, resulting in two-way intra-industry trade in differentiated goods (*trade equilibrium*);
- Expression (3.2) = 0. In this case, some fraction $\alpha(F,T,D)$ of all firms exports to the foreign market, while the others are multinationals (*mixed equilibrium*). The fraction of firms that export increases (decreases) the lower (higher) are transport costs and trade barriers and the size of each market, and the higher (lower) are fixed plant costs:

$$\frac{X}{S+X} = \frac{\alpha(\cdot)e^{(T+D)(1-\sigma)}}{1-[1-\alpha(\cdot)]e^{(T+D)(1-\sigma)}} \tag{3.3}$$

where *X* and *S* denote exports and local affiliate sales, respectively.

Brainard uses the following equation to test the proximity-concentration trade-off empirically:[53]

$$\begin{aligned} EXSH_{ij} &= \alpha_0 + \alpha_1 FREIGHT_{ij} + \alpha_2 TARIFF_j + \alpha_3 PWGDP_{ij} + \alpha_4 TAX_j \\ &+ \alpha_5 TRADE_j + \alpha_6 FDI_j + \alpha_7 PSCALE_i + \alpha_8 CSCALE_i + \mu_{ij} \end{aligned} \tag{3.4}$$

where *EXSH* is the log of the share of exports from country *i* in total foreign sales (affiliate sales plus export sales) from country *i* in country *j*; $FREIGHT_{ij}$ is the log of the

[53] Our subscript notation is slightly different from Brainard (1997) so as to keep notation consistent throughout the study.

freight factor between country i and country j; $TARIFF_j$ is the log of the foreign average tariff on imports in country j. $TRADE_j$ and FDI_j are logged measures of trade and FDI openness, where $TRADE_j$ captures the absence of non-tariff barriers and other trade barriers. TAX_j is the log of the average effective corporate income tax rate in j. Higher taxes in the destination country are expected to have a negative effect on affiliate sales since they increase the cost of local investment. Scale economies are explicitly measured.[54] $PSCALE_i$ and $CSCALE_i$ are the log of plant scale economies and corporate scale economies, respectively.

While the proximity-concentration model assumes symmetry in factor endowments, Brainard does include the difference in per-worker GDP between the countries ($PWGDP_{ij}$) in the empirical specification to control for factor-proportions differences. If traditional Heckscher-Ohlin explanations of trade or FDI apply, the effect of per capita GDP differentials on affiliate sales and exports should be positive. If, on the other hand, the Linder effect prevails, the effect of per capita GDP differentials on affiliate sales and exports should be negative (FDI and exports will be between countries with similar levels of per capita income). Because all affiliate sales are – due to scale economies – in the differentiated sector, while trade might in principle[55] occur in both homogeneous and differentiated goods, Brainard expects affiliate sales to be better explained by the Linder effect.

Lastly, Brainard includes a number of additional controls. First is a dummy variable indicating whether countries share a common language (*LANG*). This serves as a general control for cultural familiarity. Next is a dummy indicating whether a country has had a political coup in the last decade (*COUP*) to proxy political risk. Two final controls are dummies capturing adjacency (*ADJ*) and EU membership (*EC*).

To check whether the proximity-concentration hypothesis is correct, Brainard also estimates equation (3.4) for the share of affiliate sales from country i in total foreign sales.[56] This should yield a reversed sign pattern on the explanatory variables.

Using shares Brainard avoids the problem of simultaneity between affiliate production and exports encountered in earlier studies.[57] Many studies investigating the

[54] A more common approach (cf. the knowledge-capital model and gravity models more generally) is to include *GDP* as a measure of country size.

[55] The model assumes symmetry in factor endowments and consumer preferences, as well as constant returns to scale in the homogeneous sector. Hence, in this particular version of the model there is little incentive for firms to trade in the homogeneous sector.

[56] Brainard uses a generalised tobit specification to estimate affiliate shares. The dependent variable export share incorporates observations of both pure trade and mixed equilibria. The reason is that the data on exports (or imports) do not distinguish between a pure trade equilibrium and a mixed equilibrium. To ensure that there is a mixed and not a pure trade equilibrium when estimating the share of affiliate sales, Brainard first estimates the probability that affiliate sales exist and then the share of affiliate sales in total foreign sales when a mixed equilibrium is observed.

[57] She does also estimate specifications with levels. She uses two-stage least squares. The effect of trade and investment barriers and scale economies on levels of affiliate sales and trade (exports and imports) is similar to their effect on shares. The estimated effect of transportation costs on trade is higher for levels than shares, while the effect on affiliate sales is lower for levels than shares.

relationship between trade and FDI typically regress exports on FDI and a host of other explanatory variables.[58] A solution to the simultaneity problem is using instrumental-variables estimation, but instruments must ideally satisfy three conditions (Head and Ries, 2004): the instrument must be correlated with FDI; not itself simultaneously determined with exports; holding FDI constant, the instrument must have no effect on exports. The third condition is hard to satisfy (Head and Ries, 2004).

Brainard estimates equation (3.4) using data on outward activity (outward affiliate sales and exports) and inward activity (inward affiliate sales and imports) of the U.S. The results provide broad support for the proximity-concentration hypothesis for both the outward and inward equations. Affiliate sales increase relative to exports the higher are transport costs and trade barriers, indicating that firms choose local presence over exporting when the costs of the latter are high. On the other hand, the share of affiliate sales is decreasing in investment barriers. The results also provide strong support for the effect of scale economies on affiliate sales: the share of affiliate sales decreases the higher are scale economies at the plant level and increases the higher are scale economies at the corporate level. The tax variable on the other hand has the predicted sign only in the case of inward activity. However, it is not possible to reject a model with only country and industry effects, both in the case of outward and inward equations.

The results also indicate that per-worker income differentials (*PWGDP*) reduce the share of affiliate sales as well as the probability of observing any affiliate sales. In other words, affiliate sales are better explained by the Linder hypothesis and factor-proportions similarities. Brainard concludes that this evidence is inconsistent with the factor-proportions differences motive for vertical FDI.

As mentioned above a language dummy *LANG* is included to control for cultural familiarity, *COUP* proxies political risk. Both variables are expected to be particularly important for FDI. The results are in accordance with the predictions. The affiliate share (export share) is increasing (decreasing) in the language dummy. The reverse is true for

[58] These studies usually find a positive relationship between exports and FDI, suggesting a complementary relationship (e.g. Lipsey and Weiss, 1981 and 1984, Swedenborg, 1979 and 1982, Blomstrom et al., 1988). Yet, examining the relationship between exports and FDI at the appropriate level of aggregation is the key (Swenson, 2004). Blonigen (2001) uses data at the product level for Japanese automobiles and parts. He finds a substitutive relationship. Swenson (2004) extends the results of Blonigen universally across the broad spectrum of products. At the same time, Swenson finds the familiar complementary relationship when foreign investment aggregation is left at the high level of overall manufacturing. Besides, Amiti and Wakelin (2003) show the importance of distinguishing different types of FDI. Trade and FDI are likely to be complements when FDI is vertical, and substitutes when FDI is horizontal. Amiti and Wakelin show that investment liberalisation stimulates exports when countries differ in relative factor endowments and trade costs are low. These are the conditions in which the knowledge-capital model (see Section 3.3) predicts that vertical FDI will dominate. On the other hand, investment liberalisation reduces exports when countries are similar in terms of relative factor endowments and size, and trade costs are moderate to high. In this case, the knowledge-capital model predicts that horizontal FDI dominates. Alternatively, a few studies use a cross-price elasticity approach. When FDI or trade increases in response to an increase in the 'price' (variables reflecting the cost of FDI and exports) of the other, the two are substitutes. In contrast, the two are complements when an increase in the price of the one leads to a increase in the 'demand' for the other (Head and Ries, 2004). Examples include Grubert and Mutti (1991), Belderbos and Sleuwaegen (1998) and Amiti and Wakelin (2003).

the coup dummy: a political coup in the last decade has a negative effect on the share of affiliate sales and a positive effect on the export share. The coefficients are statistically significant as well, except for the *COUP* variable in the case of U.S. inward activity.[59]

Helpman et al. (2004) extend the model in Brainard (1997) by taking into account firm heterogeneity besides the standard variables of the proximity-concentration trade-off. They show that firms sort into different organizational forms according to productivity. Low-productivity firms serve only the domestic market. The remaining firms serve both foreign and domestic markets. Yet, only the most productive ones in this group choose to invest in foreign markets. The less productive firms choose to export. The empirical analysis for U.S. multinationals in Helpman et al. confirms that in sectors with large differences in productivity there is relatively more FDI than exports.[60]

3.5. Review of the existing literature on bilateral FDI

In Sections 3.3 and 3.4 we merely presented the knowledge-capital model and the proximity-concentration trade-off. In this section we evaluate the two models of bilateral FDI and the empirical work related to them. There are three main issues in this literature that warrant further investigation. The first issue has to do with the use of FDI data; the second with the assumptions and empirical specification of the knowledge-capital model; and the third with the specification of distance in the proximity-concentration model.

[59] The latter is very plausible given that political instability of the host country is more of an issue from the perspective of American MNEs than the other way around.

[60] Empirical work in the trade literature indicates that the causality runs from the ex ante performance of the firm to export performance, rather than the other way around. The seminal paper on the causality between export and productivity is Bernard and Jensen (1999). Using data for American firms, they find that exporting plants and firms show superior performance characteristics relative to non-exporters. Several years before they actually ship any goods abroad, future exporters are larger, more productive and they pay higher wages to all types of workers. In the years just prior to the start of exporting, they also grow faster than their non-exporting counterparts. This pattern is confirmed by subsequent studies for other countries: exporting firms are more productive and the higher productivity is manifest prior to exporting. Greenaway and Kneller (2005) and Wagner (2006) give overviews of the literature. On the other hand, the literature is less unanimous about the reverse causality, i.e. the performance of plants once they become exporters. Bernard and Jensen (1999) investigate the impact of exporting on performance by comparing performance characteristics of exporters with those of non-exporters. Employment growth is significantly higher for exporters (in the short run, medium and long run) and they have significantly lower failure rates than non-exporters with similar characteristics. However, as indicated by Bernard and Jensen, most plant attributes, especially productivity, grow no faster, and even slower, at today's exporters. This is especially the case in the long run. In principle, only the moment of entry is a time of growth and improved performance. Greenaway et al. (2005) summarise the results of the additional literature as follows: a small number of studies (Castellani, 2002, Kraay, 1999, Girma et al. 2004) report that export intensity matters: the productivity premium increases as the share of output exported increases. There is a growing body of evidence to suggest a further increase in productivity following entry, albeit for specific (e.g., young) firms (e.g., Kraay, 1999, Castellani, 2002) or certain time periods (Girma et al., 2004).

3.5.1. U.S. bilateral FDI

A first observation concerning the literature presented above concerns the FDI data that are used. The empirical contributions by Brainard (1997), Carr et al. (2001), and Markusen and Maskus (2002) presented above all use data on affiliate sales from the U.S. Bureau of Economic Analysis (BEA). The advantage of using affiliate sales over, e.g., FDI stocks is that they may be a better measure of multinational activity. Lipsey points out that data on FDI stocks "do not purport to measure the size of multinational firms or their foreign affiliates, or their activities in their host countries. They measure only the value of the parent firms' financial stakes in their foreign affiliates" (Lipsey, 2001, p.14).[61] A drawback of using affiliate sales is that detailed data on the activities of foreign affiliates is only sparsely or not available for countries other than the U.S. As a result, data are bilateral with the U.S. only. This leaves out many observations of FDI between other countries.

3.5.2. The knowledge-capital model and the role of skilled labour

The knowledge-capital model is Markusen's instrument for explaining the stylised fact that the overwhelming share of world investment in between high-income, developed economies. The explanation is that FDI is of a predominantly horizontal nature. As explained above, the knowledge-capital model predicts that horizontal FDI dominates when countries are similar in size and relative skill endowments.

The distinctive feature of the knowledge-capital model is that, within aggregate FDI, it distinguishes between horizontal and vertical FDI. To capture the distinction between horizontal and vertical FDI, the empirical specification in CMM imposes a certain structure on the data. This is illustrated by comparing the empirical specification of the knowledge-capital model with a standard gravity equation. Box 3.1 presents the gravity equation.

[61] On the other hand, matters may not be so bad after all. Blonigen and Davis (2004, note 17) report a strong correlation between U.S. bilateral affiliate sales and U.S. bilateral FDI stock: 0.92 for inbound FDI activity and 0.90 for outbound FDI.

Box 3.1. The gravity model

The gravity model is the most commonly used model in the empirical literature to explain variation in trade or investments between countries. Following Newton's gravity equation in physics, which relates the gravitational force between two bodies proportionately to the product of their masses and inversely to the square of the distance between them, standard gravity equations typically link bilateral flows of some sort between two partners to their combined economic size (increasing function) and (negatively) to the geographic distance. A standard gravity model of bilateral FDI is given by

$$FDI_{ij} = K \frac{Y_i^{\alpha} Y_j^{\beta}}{D_{ij}^{\delta}}, \tag{1}$$

where FDI_{ij} denotes FDI from country i to j, K is a scalar, Y presents the level of GDP and D_{ij} reflects distance between the two countries. Considering a loglinear model to deal with heteroskedasticity is very common when the size of observations differs substantially (Verbeek, 2004). This is typically the case in data on trade or FDI. The transformed basic gravity equation used in estimation then becomes:

$$\ln(FDI_{ij}) = \ln(K) + \alpha \ln(Y_i) + \beta \ln(Y_j) + \delta \ln(D_{ij}) + \varepsilon_{ij}. \tag{2}$$

In the trade literature the theoretical foundations for the gravity equation have been established in a series of papers (e.g., Anderson, 1979, Bergstrand, 1985, Anderson and Van Wincoop, 2003). The theoretical models of FDI discussed in this chapter are also gravity-type models, each in their own specific way.

In the empirical literature, the gravity equation is the most commonly used model to explain the variation in trade or investments flows between countries. As with trade flows, the gravity equation fits the data on FDI well (Blonigen, 2005).[62] The knowledge-

[62] Bergstrand and Egger (2007) show that both trade and FDI are well approximated by (different specifications of) a trade gravity equation. This result presents a puzzle. It implies that both trade and FDI increase in GDP size and similarity. However, the knowledge-capital model predicts that horizontal FDI attains a maximum when two countries are of equal size and factor endowments. In this case, horizontal MNEs (HMNEs) completely displace national, exporting firms. Bergstrand and Egger solve the puzzle by introducing to the 2x2x2 knowledge-capital model a third factor, physical capital, and a third country. They assume that plant set-ups are relatively more physical-capital intensive, whereas headquarter set-ups are relatively more human-capital intensive. Let's start by assuming that some parent i is large relative to host j. In this case, the host market j will be most profitably served through exports by national firms. If, however, the share of $j(i)$ increases (falls), it becomes more profitable to serve j by horizontal investments to avoid trade costs. Nothing new so far. The key in the 3-factor model is that a change in the countries' size causes trade and FDI to move in opposite

capital model by and large gives theoretical foundations for a gravity-type equation to explain the pattern of FDI across countries. Still, compared to a standard gravity model, the empirical specification of the knowledge-capital model is rather complex. The empirical specification in CMM (i) imposes linear constraints on the coefficients of parent and host country GDP, and of parent and host country skilled-labour abundance; and (ii) includes interactions between variables. To allow for such interaction terms, CMM do not log the data, but use a linear specification instead. To what extent do the data support such a structure, in particular in the face of other data than the data on U.S. bilateral affiliate sales?

A second issue is that vertical FDI may in practice also be directed towards countries with relative skill *abundance*, depending on the industry. Yeaple (2003) re-estimates a model of U.S. outward FDI similar to Brainard (1997). The novelty of his approach is that he inter-acts the relative skilled-labour abundance of countries with the skilled-labour intensity of sectors. The interaction enters the estimation equation through the unit costs of production. Yeaple assumes that low cost of production attracts FDI.

Multinational firms operating in high-skilled-labour intensive industries are then expected to be attracted to skilled-labour abundant countries, and multinationals operating in low-skilled-labour intensive industries are expected to be attracted to skilled-labour scarce countries. He finds that "in industries with high skilled-labour intensities, U.S. multinationals favour skilled-labour abundant countries over skilled-labour scarce countries, whereas in sectors with low skilled-labour intensities U.S. multinationals favour skill-scarce countries over skilled-labour abundant countries" (Yeaple, 2003, p. 727). This evidence indicates that U.S. multinationals locate types of production abroad in a manner that exploits host countries' particular comparative advantage. It follows from Yeaple's results that, to the extent that FDI occurs in skill-intensive industries, vertical FDI will also be directed towards countries with relative skill *abundance* rather than relative skill scarcity. Vertical FDI as defined in the knowledge-capital model, i.e. the relocation of production to relatively skilled-labour *scarce* countries, will then show up significantly only in labour-intensive industries. Yeaple's results imply that vertical FDI may very well be driven by skill similarities too, depending on the industry. Thus, the distinction between horizontal and vertical FDI on the basis of skill differences/similarities may not be so sharp in practice.

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directions. As single-plant national firms (NE) are being increasingly replaced by HMNEs, as the two countries become more similar, the relative demand for physical capital increases and that for human capital declines. "A higher price of physical capital in *i* raises the relative price of multi-plant HMNE firm set-ups, *reducing* the displacement of single-plant national firms and helping to secure their coexistence with HMNEs. Second, a lower price of human capital in *i* lowers the price of HMNE and NE firm set-ups, also securing coexistence of both types of firms" (Bergstrand and Egger, 2007, p. 294). Adding a third country sharpens the increase (fall) in the price of physical (human) capital thereby dampening the increase in HMNEs and the decrease in NEs more.

3.5.3. The proximity-concentration trade-off and the specification of distance

The proximity-concentration trade-off hypothesis states that FDI substitutes for trade if distance between countries is large, while exports become more important if scale economies in production are large. The model is in essence a model of international trade. It builds on the notion that international trade decreases with 'distance' as predicted by the gravity model. When distance increases, firms will rely relatively more on FDI to access foreign markets. The proximity-concentration trade-off hypothesis pays relatively little attention to the fact that FDI may incur costs related to distance of its own.[63]

In economic terms, distance affects international transactions through various channels. The most obvious dimension of distance is physical distance, which conditions bilateral trade because it raises transport costs. We divide other factors that raise distance between countries into tangible and intangible barriers. Trade policy barriers (tariff and non-tariff barriers) and currency exchange barriers are examples of tangible barriers to trade. Examples of intangible barriers to trade include incomplete information barriers, cultural barriers and institutional barriers (Anderson and Van Wincoop, 2004).

Recently, the trade literature has considered explicitly the role of intangible trade barriers in explaining patterns of bilateral trade (e.g., Anderson and Marcouiller, 2002, Loungani et al., 2002, Anderson and Van Wincoop, 2004, De Groot et al., 2004). The importance of search costs and networks in trade (see, e.g., Rauch, 1999, 2001) illustrates the importance of information costs for patterns of trade. The effect of cultural barriers consists of two aspects, cultural unfamiliarity and cultural distance. Much like other sources of incomplete information, unfamiliarity with foreign cultures leads to search costs and adjustment costs incurred in international interactions. Apart from that, distance in terms of cultural values and norms, causes barriers related to trust and understanding (Linders et al., 2005). Institutions influence the uncertainty surrounding transactions and hence the costs associated with this. The quality of institutions affects expropriation risks, the degree of corruption, the enforceability of private contracts, and hence the security of trade (see Anderson and Marcouiller, 2002). Cultural and institutional barriers are relevant for FDI for much the same reasons as for trade (see, e.g., Barkema and Vermeulen, 1997; Globerman and Shapiro, 2003). In fact, these factors determine the cost of doing international business *as such*.

Table 3.2 summarizes the results of some recent studies that examine the effects of institutional and cultural barriers on both trade and FDI.[64]

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[63] Brainard does include a language dummy to control for cultural familiarity and a dummy indicating whether a country has had a political coup in the last decade to proxy political risk. The share of sales associated with FDI (export sales) is increasing (decreasing) in language similarity and decreasing (increasing) in political risk, as expected.

[64] The overview is not exhaustive. It focuses on the most recent studies and studies that include variables of both institutional and cultural barriers.

Table 3.2. Overview effects culture and institutions in the literature

	Relation	Estimate	Control variables	Institutions	Country sample
Guiso et al. (2005)	Mutual trust and trade	Positive (**)	Exporting and importing country fixed effects, time fixed effects and industry fixed effects; the presence of a common border and of a common language; availability of information and common origin of law	Effect common origin of law Positive (**)	EU
	Mutual trust and FDI	Positive (**)		Effect common origin of law Positive (stat. insignificant)	
CPB (2007)	Cultural distance and trust on trade	Cultural distance: Negative (stat. insignificant) Trust: Positive (***)	Common language, common border, institutional distance, institutional quality origin & destination		OECD
	Cultural distance and trust on FDI	Cultural distance: Negative (***) Trust: Positive (***)			
Linders et al. (2005)	Cultural distance and trade	Positive (***)	Common border, regional bloc dummy, common language, colonial link dummy, religion dummy, institutional distance, institutional quality origin & destination	Institutional distance: Negative (***) Inst. quality exporter: Positive (***) Inst. quality importer: Positive (***)	'world'

* significant at 10%; ** significant at 5%; *** significant at 1%

The table suggests that intangible barriers matter for both exports and FDI. The effects of the cultural and institutional variables are commonly significant, even with a host of control variables or even fixed effects (Guiso et al., 2005). Linders et al. (2005) find a positive (and highly significant) effect of cultural diversity on exports. This result may be explained by a substitution-effect: if the costs of cultural distance weigh heavier on local presence than on exports, firms substitute exports for sales by local affiliates. The results in Table 3.2 underline the importance of mutual trust, security of trade, and cultural diversity in explaining total observed bilateral interactions between countries.

3.6. Contributions of Part II and outline of empirical analysis

In this section we present the extensions and contributions to the existing literature in Part II of this study and we give an outline of the empirical analysis in Chapters 4–6.

3.6.1. FDI of the OECD

The first contribution of this study pertains to data: throughout Part II, we use data on bilateral FDI stock of the OECD. Data are from the International Direct Investment Statistics database of the OECD.[65] This significantly increases the amount of observations on bilateral FDI. This is illustrated in Figure 3.1. Figure 3.1 gives the distribution (in per cent) of total outward FDI stock from the OECD to a large number of partner countries (OECD and non-OECD) in the period 1982–1992.[66] Figure 3.1 distinguishes between the U.S. and OECD excluding the U.S. The light-shaded areas indicate bilateral FDI involving the U.S. (as a parent or host country). This amounts to 60 per cent of total FDI from the OECD. But, the OECD data also include observations on FDI not involving the U.S. (indicated by the dark-shaded areas in Figure 3.1). This accounts for another 40 per cent of total outward FDI stock. Hence, using bilateral FDI data of the OECD entails an increase in observations on bilateral FDI by two-thirds compared to using data that are bilateral with the U.S. only.

Table 3.3 presents the minimum and maximum set of countries in the different regressions of bilateral FDI in this study.

[65] The data were kindly provided by Bruce Blonigen.

[66] There are no observations on FDI from non-OECD countries. However, in Chapter 1 we calculated that the OECD accounts for 85 per cent of total outward stock in the period 1980–2006. In other words, FDI from the OECD accounts for the bulk of outward FDI.

Figure 3.1. Distribution of FDI stocks from OECD in 1982–1992 by parent and host country, per cent

Parent	Host	OECD: U.S.	OECD: OECD excl. U.S.	Non-OECD	Total parent
OECD	U.S	0	**30**	**5**	35
OECD	OECD excl. U.S.	**25**	**32**	**8**	65
Non-OECD		n.a.	n.a.	n.a.	n.a.
	Total host	25	62	13	100

Table 3.3. Countries in sample

Parent (OECD)	Host countries (OECD and non-OECD)		
Australia	Australia	Indonesia	Spain
Austria	Austria	Ireland	Sweden
Canada	Belgium/Luxembourg	Israel	Switzerland
Finland	Brazil	Italy	Thailand
France	Canada	Japan	Turkey
Germany	Chile	Korea	UK
Iceland	China	Malaysia	USA
Italy	Colombia	Mexico	Venezuela
Japan	Denmark	Morocco	***Plus*:**
Korea	Egypt	The Netherlands	Argentina
The Netherlands	Finland	Nigeria	Iceland
Norway	France	Norway	New Zealand
Sweden	Germany	Philippines	Panama
UK	Greece	Portugal	Saudi Arabia
USA	India	Singapore	UAE [a]

[a] United Arab Emirates

3.6.2. Transforming FDI stocks into sales using capital-output ratios

The OECD data on FDI represent FDI stocks. As mentioned above, FDI stocks measure the value of the parent firms' financial stakes in their foreign affiliates. They do not (necessarily) measure the size of multinational firms or their foreign affiliates, or their activities in their host countries. Affiliate sales are thought to be a better measure of multinational activity. It also allows for a comparison of local sales through FDI and exports. Still, data on affiliate sales is available for the U.S. but sparse or unavailable for other countries.

This study *derives* measures of FDI sales. We use capital-output ratios to transform FDI stocks into a measure of FDI-related sales in the foreign market. Comparison of data on affiliate sales from the BEA and our measures of FDI-related sales for the U.S. shows high levels of correlation: 0.99 or 0.90 in the case inward FDI sales, and 0.85 or 0.92 for outward sales.[67] The calculation is based on data for 1990. FDI sales are used in Chapter 6 (see below).

3.6.3. Multilevel analysis

An issue in the data used in Part II is dependence. The data is a panel data set for multiple parent and host countries, so we have repeated observations: for parents over all host countries, for host countries over all parents, for parent and host countries over time, and for specific parent-host combinations. The issue of clustering of observations in bilateral trade and FDI data has remained largely unaddressed in the literature on trade and FDI. Failure to take correlation of observations into account leads to an underestimation of the standard errors of the regression coefficients and can result in spuriously significant results. Even small levels of correlation can cause the standard errors from OLS to be seriously biased downwards (e.g., Moulton, 1990, Barcikowski, 1981).

This study uses multilevel techniques to account for clustering of observations of FDI within parent and host countries and parent-host combinations. Chapter 4 explains the multilevel approach and fits a multilevel version of the knowledge-capital model to the FDI data of the OECD. Doing so extends the analysis in Blonigen et al. (2003).[68] The latter estimate the knowledge-capital model using the FDI data used in this study, but their estimates are obtained by OLS. In Chapters 5 and 6, multilevel estimation is used as an additional robustness analysis.

[67] Depending on whether the capital-output ratio of the parent country or the host country is used.
[68] See also Section 3.6.6 below.

3.6.4. Robustness analysis of knowledge-capital model with OECD data

In Chapter 5 we test the empirical specification of the knowledge-capital model. Are the linear constraints imposed in the empirical specification supported by data on FDI of the OECD? And how appropriate is the linear form of the model? In the second part of the chapter we investigate the importance of size and skilled labour as sources of attraction for FDI using a gravity model.

3.6.5. Culture and institutions and the mode of serving foreign markets

Chapter 6 extends the empirical framework for analysing the trade-off between exports and FDI. Our approach explicitly takes into account intangible barriers related to cultural and institutional differences. Unlike the mechanisms described by the conventional proximity-concentration hypothesis, these ‘intangible’ barriers can affect the costs related to FDI as well as trade. The regressions include multiple dimensions of distance suggested by the literature on international trade as control variables.

3.6.6. Indicator sets in Chapter 4 and 5

Chapters 4 and 5 empirically investigate the knowledge-capital model using the FDI data of the OECD. In these analyses we use two indicator sets for the explanatory variables. First is the indicator set in Blonigen et al. (2003). In fact, we are not the first to use the FDI data of the OECD. Blonigen et al. (2003) estimate the knowledge-capital model using the FDI data used in this study. Still, the main purpose in Blonigen et al. (henceforth referred to as BDH) is to show that estimating a version of the knowledge-capital model with *absolute* size and skill differences rather than a version with simple differences like the CMM specification, no longer supports the knowledge-capital model but simply favours of a horizontal model. The estimations with the OECD data merely serve as a robustness check to strengthen this point. A more in-depth analysis of the estimations or the data like this study does (i.e., taking into account the clustering of the FDI data and a robustness analysis of the knowledge-capital model as such) is not given. The estimations in BDH serve as a benchmark in Chapters 4 and 5. In addition to the BDH indicators we use the indicators of skilled-labour abundance, trade and investment costs used in CMM in Chapters 4 and 5 to check the robustness of our results with the BDH indicators.

In the estimations of the gravity model in Chapter 5, we also use the measure of schooling quality *QL* by Hanushek and Kim (1995) *in addition to* the BDH and CMM indicators of human capital and skilled-labour abundance, respectively. *QL* adjusts for quality differences in human capital across countries whilst the Barro and Lee indicator merely measure the quantity (years) of schooling. Hence, *QL* gives a better indication of the stock of human capital than the Barro and Lee indicators.

Part II

Empirical Analysis of Bilateral FDI

4

Bilateral FDI and Clustering – a Cross-Classified Multilevel Approach[69]

4.1. Introduction

The data to be used in Part II of this study is a panel data set. The use of panel data has become increasingly prominent in the empirical literature (see, e.g., Baltagi, 1995, Hsiao, 2003, Verbeek, 2004). The use of a panel data set will generally yield more efficient estimators than cross-sectional or time series data because data vary over two dimensions, countries and time. In addition, with panel data, one can control for time invariant country-specific effects (e.g., Egger, 2000). An issue that has remained largely unaddressed in the literature is the clustering of observations. Because we repeatedly observe the same units, it may no longer be appropriate to assume that observations are independent (Verbeek, 2004, Ch. 10). Failure to take correlation of observations into account leads to an underestimation of the standard errors of the regression coefficients and can result in spuriously significant results. Even small levels of correlation can cause

[69] This chapter is based on Lankhuizen et al. (2008).

the standard errors from OLS to be seriously biased downwards (e.g., Moulton, 1990, Barcikowski, 1981).[70]

We use multilevel techniques to account for clustering of observations in this study. In particular, we use the analogy of a cross-classified multilevel model. The data used in Part II of this study is a panel data set for multiple parent and host countries. This means we have several repeated observations: for parents over all host countries, for host countries over all parents, for parent and host countries over time, and for specific parent-host combinations. The cross-classified multilevel model in this study accounts for clustering of FDI within parent and host countries and parent-host combinations.

This chapter introduces the multilevel approach and fits a cross-classified multilevel version of the knowledge-capital model to the FDI data of the OECD. Doing so extends the analysis in Blonigen et al. (2003). The latter estimate the knowledge-capital model using the FDI data used in this study, but their estimates are obtained by OLS.

The chapter is organised as follows. Section 4.2 explains the multilevel approach and describes the cross-classified multilevel model to be used in this chapter. Section 4.3 addresses the issue of consistency of the regression coefficients. Section 4.4 presents the estimation results. We compare the estimates of the cross-classified multilevel approach with cluster-robust linear regression. In Section 4.5, we interpret the effects on FDI of the explanatory variables implied by the knowledge-capital model. Section 4.6 summarises our main conclusions.

4.2. Cross-classified multilevel regression model

Multilevel models deal with hierarchical data structures. Hierarchical data are often found in social science research. Consider, e.g., a population consisting of schools and pupils within these schools. In this example, pupils (level 1) are clustered, or nested, within schools (level 2). In addition, schools may be nested in yet a higher level like, e.g., districts or countries. This is an example of a strict hierarchy. Data structures need not always be strictly hierarchical as in the previous example. Pupils can be nested within other level-2 units *alongside* schools, e.g., the area in a city they live in (neighbourhoods). School and area are two parallel higher-level units: pupils attending the same school are not necessarily from the same area and vice versa. This is an example of a cross-classified data structure. Graphical representations of these examples are given in Appendix 4B.

[70] Barcikowski (1981) illustrates what happens to the true probability of making a type-I error in statistical testing when intra-class correlation is ignored. Assume that OLS results indicate that the *p*-value of a coefficient is 0.05. If one has a sample with N=10 observations and an intra-class correlation of 0.01, the true *p*-value is 0.06. If, however, one has 100 observations and an intra-class correlation of 0.20, the true *p*-value is 0.70.

Multilevel models model variability at each level of the hierarchy (Houchens et al., 2007).[71] They take into account that higher-order heterogeneity may have an impact on the dependent variable. If, in the example above, the dependent variable is school performance of pupils, then school effects (level 2) may be every bit as important in explaining the variation in performance as the characteristics of the pupils (level 1). Second, they also take into account that, because of these school (or area) effects, pupils going to the same school (from the same area) tend to be more like each other than pupils chosen at random from the population of children at large (Fielding and Goldstein, 2006). Multilevel models thus also take clustering into account.

This chapter uses the analogy of a cross-classified multilevel model (see, e.g., Snijders and Bosker, 1999, and Raudenbush and Bryk, 2002, Ch. 12) to estimate the knowledge-capital model. In this study, we presume that observations of FDI over time are nested in the higher-level units: parents, hosts, and parent-host combinations. That is, the general idea of the multilevel analysis taken in this study is that higher-level parent, host or parent-host-combination heterogeneity has an impact on the dependent variable. Next, that because of these higher-level effects, 'years' (annual FDI values) for the same parent country *i*, host country *j*, or the same parent-host combination tend to be more alike.

We estimate a random intercept model with two main effects (parent and host countries) and a parent-by-host interaction effect.[72] We start from a baseline model that has no independent variables (predictors). For level-1, the baseline model for the bilateral FDI stock in a given year *t* from parent country *i* to host country *j* can be written as:

$$FDI_{t(ij)} = b_{0(ij)} + \varepsilon_{t(ij)}, \tag{4.1}$$

where $\varepsilon_{t(ij)} \sim N(0, \sigma_{\varepsilon}^2)$.

In equation (4.1),

$b_{0(ij)}$ represents the 1982–1992 period mean value of the bilateral FDI stock, i.e., the mean of the yearly figures for the interval 1982–1992, in host country *j* originating from parent country *i;*

[71] See Appendix 4B for an explanation of the basic ideas of multilevel analysis through a simple example.

[72] Multilevel models also allow slopes to be random. We have no theoretical reason to assume that the effects of the explanatory variables in the knowledge-capital model vary across different country groups and combinations, i.e. random slopes, so we do not pursue this route. But this point serves to illustrate the flexibility of multilevel modelling.

$\varepsilon_{t(ij)}$ represents the individual year residual, i.e. the deviation of the FDI stock in year t from mean value $b_{0(ij)}$ for parent country i and host j.

In simple OLS, instead of $b_{0(ij)}$, a constant or "non-varying" intercept b_0 is used, while in multilevel models $b_{0(ij)}$ is typically assumed to vary randomly across higher level units, which, in the present case, are host and parent countries and parent-host combinations. For level-2, the baseline model for the 1982–1992 mean FDI stock in host country j originating in parent country i is written as:

$$b_{0(ij)} = b_{00} + p_{0i} + h_{0j} + c_{0ij}, \tag{4.2}$$

where,

b_{00} is the grand mean, i.e. the expected FDI amount invested by a randomly selected parent country in a randomly selected host country, in a randomly selected year;

p_{0i} is the deviation of parent country i from grand mean b_{00}, where $p_{0i} \sim N(0, \sigma^2_{0p})$ and $b_{00} + p_{0i}$ is the 1982–1992 mean investment of (parent) country i collapsed over host countries;[73]

h_{0j} is the deviation of host country j from grand mean b_{00}, where $h_{0j} \sim N(0, \sigma^2_{0h})$ and $b_{00} + h_{0j}$ is the 1982–1992 mean investment in (host) country j collapsed over parent countries;

c_{0ij} is a random interaction effect, i.e., the deviation from grand mean b_{00} that is not fully captured by the main deviations p_{0i} and h_{0j}, where $c_{0ij} \sim N(0, \sigma^2_{0ph})$.

The term c_{0ij} captures that parent and host countries may interact in their effects on $FDI_{t(ij)}$. That is, the effect of a parent may be different for different host countries and vice versa. In either case the ij means cannot be modelled simply by knowing the size of the main effects. An additional parameter must be used. This parameter is called an interaction (Stockburger, 1996). In our context, c_{0ij} essentially captures the effect on FDI of parent-host combinations. The variances σ^2_{0p}, σ^2_{0h} and σ^2_{0ph} represent the amount of heterogeneity in the 1982–1992 mean FDI stock values attributable to the main effects parent and host country and to parent-by-host interaction, respectively.

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[73] The multilevel model assumes that expected values of the level-2 random effects are zero. If this is the case, the level-2 random effects and the explanatory level-1 variables are uncorrelated and the level-1 estimators will be consistent (Snijders and Berkhof, 2007). See Section 4.3 for a treatment of consistency.

By substituting equation (4.2) in (4.1), we obtain the following overall baseline model:

$$FDI_{t(ij)} = b_{00} + p_{0i} + h_{0j} + c_{0ij} + e_{t(ij)}. \tag{4.3}$$

Model (4.3) is often called the 'variance component' model. The total variance in $FDI_{t(ij)}$ is decomposed into different components, $\sigma^2_{0p} + \sigma^2_{0h} + \sigma^2_{0ph} + \sigma^2_e$: variance *between* parent countries σ^2_{0p}, variance *between* host countries σ^2_{0h}, and the residual *between*-variance σ^2_{0ph} (i.e., the variance *between* parent-by-host combinations), and the *within*-variance σ^2_e in FDI, that occurs between years for parent country i and host j. By accounting for the between-country variances, the multilevel model deals with the clustering in the data. Departing from baseline model (4.3), the correlation of two FDI values drawn from the same parent country, host country or the same parent-host combination can be written as $\sigma^2_{0p}/(\sigma^2_{0p} + \sigma^2_{0h} + \sigma^2_{0ph} + \sigma^2_e)$, $\sigma^2_{0h}/(\sigma^2_{0p} + \sigma^2_{0h} + \sigma^2_{0ph} + \sigma^2_e)$ and $(\sigma^2_{0p} + \sigma^2_{0h} + \sigma^2_{0ph})/(\sigma^2_{0p} + \sigma^2_{0h} + \sigma^2_{0ph} + \sigma^2_e)$, respectively (see Raudenbush and Bryk, 2002).

By adding to model (4.4) the explanatory variables we are able to explain the variances in FDI. Building on Carr et al. (2001), we specify the following multilevel version of the knowledge-capital model:

$$\begin{aligned} FDI_{t(ij)} &= b_{00} + p_{0i} + h_{0j} + c_{0ij} + \\ & b_1 SUMGDP_{t(ij)} + b_2 GDPDIFF^2_{t(ij)} + b_3 SKDIFF_{t(ij)} + \\ & b_4 GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)} + b_5 INVCH_{t(j)} + b_6 TCH_{t(j)} + \\ & b_7 TCH_{t(j)} \times SKDIFF^2_{t(ij)} + b_8 TCP_{t(i)} + b_9 DIST_{ij} + e_{t(ij)}. \end{aligned} \tag{4.4}$$

In model (4.4), the effects of parent, host and parent-host combinations are netted out, as these are represented by p_{0i} , h_{0j} , and c_{0ij} respectively. As a result, the interpretation of the coefficients b_i in (4.4) changes compared to OLS (see equation (3.1)): the multilevel model focuses on explaining the variance of FDI over the years for parent country i and host j (within-variance). The OLS-estimates The OLS-estimates include country and temporal effects. Second, for a parent/host pair ij the intercept of model (4.4) is given by the expression $b_{00} + p_{0i} + h_{0j} + c_{0ij}$. The interpretation of b_{00} has, compared to model (4.2), changed from 'grand mean' to 'grand intercept', with p_{0i}, h_{0j} and c_{0ij} now being parent, host and parent-by-host deviations from this 'grand intercept'.

An alternative way to take into account the intra-class correlations is through cluster-robust linear regression (see, e.g., Anderson and Marcouiller, 2002). Cluster-robust linear regression adjusts the standard errors of the regression coefficients to account for the loss of independence. It leaves the OLS-regression coefficients unaltered. A drawback of cluster-robust linear regression compared to the multilevel model in the face of the present data is that in cluster-robust linear regression one can only use one cluster variable at a time. Besides, it does not take into account the effects on the estimated parameter of country-specific or parent/host-specific heterogeneity. The cross-classified multilevel approach accounts for three cluster effects simultaneously.

4.3. Consistency

The multilevel model in this paper deals with intra-class correlation by accounting for the effects of parent, host or parent-host-combination heterogeneity on FDI. The multilevel model then explains the variance between years for parent country i and host j. Controlling for time-invariant country-specific effects is done frequently in the literature on international trade and FDI to check the sensitivity of the estimation results to omitted variables bias. Contrary to common practice in the gravity literature, the multilevel model captures these effects through random rather than fixed effects. An advantage of the multilevel approach over regression with fixed effects is that we can keep all variables in the specification because only the variances over countries are explicitly estimated. In the fixed effects estimation, the effect of (time-invariant) distance can no longer be estimated. Also, and related to the previous advantage, is that, because the multilevel model only estimates variances over countries and parent-host combinations, it is parsimonious with degrees of freedom. Instead, in the fixed effects regression, coefficients for each separate country and pair are estimated.

A possible drawback of random effects is the existence of correlation between the time-varying explanatory variables in (5) and the random effects p_{0i} , h_{0j} , and c_{0ij}. A crucial assumption in view of consistent estimators is that such correlation is non-existent. This is reflected by the assumption of zero expected values of the random effects. If, for example, the expected value of p_{0i} equals some non-zero value z_i, then by ignoring z_i in the regression model, the effect of z_i will be absorbed by the regression coefficients b (Snijders and Berkhof, 2008), thus creating a bias.

The Hausman-test is commonly used as test of the assumption of non-orthogonality in a random effects model. This test investigates whether the random effects estimator differs significantly from a fixed effects estimator (see, e.g., Verbeek, 2004). In general, economists are of the view that, if there is a significant difference between the random effects estimator and the fixed effects estimator, the fixed effects specification and OLS estimation should be used. However, according to Fielding (2004), abandoning a random effects framework based on a significant Hausman test is premature.[74] For one, the test is sensitive to misspecifications. A significant value for the test may thus be misleading as a diagnostic for this misspecification. Fielding (2004) points out that dropping a key variable in the model can have this effect. Also, the null distribution might not be well approximated by the asymptotic Chi-square in finite samples, which can lead to an overstated size of the test (Fielding, 2004, p. 6). Next, there are the advantages of random effects over fixed effects mentioned in the previous section, i.e. the possibility to retain all explanatory variables in a random effects model (this is particularly critical when there are strict criteria governing the addition of explanatory variables) and the fact that it is parsimonious with degrees of freedom.

What's more though, there is an alternative procedure to ensure unbiased estimators in a model with random effects. Snijders and Berkhof (2008) argue that it is useful to add the cluster means (here by parent, host and parent-host combination) of the explanatory variables as additional level-1 variables to the equation. Lack of orthogonality of the explanatory variables and an omitted z_i will materialise through these cluster means. There will be a bias due to the lack of orthogonality if the cluster means are non-zero. By adding the cluster means to the model, the orthogonality of an unobserved z_i to the cluster means can be tested implicitly by testing the null-hypothesis that the effects of the cluster means are equal to zero (Baltagi, 1995, Snijders and Berkhof, 2008).[75] Yet, Snijders and Berkhof (2008) argue that using this test for deciding between fixed or random effects is slightly beside the point: by adding the cluster means as additional explanatory variables, the random-effects model yields unbiased estimates of the within-cluster effects b.[76]

So, to ensure consistency of the estimators, we include cluster means of the explanatory variables. A few words are in order, here. In a number of cases, correlation between the explanatory variables and cluster means is very high (>0.98). In particular, such high correlations exist between the bilateral variables of the model ($SUMGDP_{t(ij)}$, $SKDIFF_{t(ij)}$, etc.) and the means by country pair; between $INVC_{t(j)}$ and $TCH_{t(j)}$ and their means by host country; and between $TCP_{t(i)}$ and its mean by parent country. Besides, distance is constant over time, so the value for a particular parent-host combination is the same across all years and is identical to the mean by country pair. This is the case in both indicator sets. Hence, we exclude eight cluster means on these grounds. In addition, high

[74] See Fielding (2004) for a more detailed review of the reservations regarding the Hausman test uncovered in the literature.

[75] This can be interpreted as testing the equality between the within-cluster regression coefficient and the between-cluster coefficient. The test for equality of the within-cluster and the between-cluster coefficients is a special case of the Hausman test (Snijders and Berkhof, 2008).

[76] We point out that the addition of the cluster means changes the characterization of the level-2 variation (Fielding, 2004). But since we are not interested in the study of the level-2 effects *themselves*, we shall not dwell on this point here. Our primary concern is with obtaining consistent estimates of b.

correlations also exist between some of the cluster means. The multilevel model cannot be estimated as a result of these high correlations. We therefore dropped cluster means that were highly correlated with another cluster mean in a step-by-step procedure, starting with cluster means that had the highest correlation until the model could be estimated. This resulted in the model being estimated with twelve (ten) cluster means for the BDH (CMM) indicator set. As it turns out in the regressions, several cluster means are statistically insignificant.[77] Although, in principle we want to include as many cluster means as possible (so as to ensure consistent estimators), we also estimated specifications that include only cluster means that are statistically significant to investigate the estimations' sensitivity for varying the number of cluster means.

4.4. Estimation results

In the estimations we use the indicator set of BDH. As mentioned in Chapter 3, the estimations in BDH provide a benchmark for our empirical analysis. To check the robustness of our results with the BDH indicators we also use the CMM indicators of skilled-labour abundance, trade and investment costs.

As argued above, the estimates of between-variances can be used to calculate correlation of observations belonging to the same parent and host country and the same parent-host combination. How large is the intra-class correlation in the FDI data? We use maximum likelihood estimation to fit the cross-classified multilevel model.[78] For the BDH indicator set Table 4.1 gives the estimates of the within-variance σ_e^2 as well as the between-variances, σ_{0p}^2, σ_{0h}^2 and σ_{0ph}^2, respectively, for two different baseline models, one including and the other excluding the interaction effect c_{0ij}. Note that the model including c_{0ij} has a much better fit in terms of the log likelihood (–2*LL*). All three variances are statistically significant.[79] Based on the estimates of this model, the correlation of two FDI values drawn from the same parent-host combination is 0.78.

[77] There is a high degree of multicollinearity even after cluster means have been excluded on *a priori* grounds as explained above. This is especially the case in the regressions with the BDH indicators.
[78] Baltagi and Chang (1994) compare alternative estimators of the variance components.
[79] To test the significance of the variances we proceed as follows (see Snijders and Bosker, 1999). We compare the log likelihood of the model including all three effects with the corresponding log likelihood value of the model without p_{0i}, h_{0j} and c_{0ij}, respectively. An effect is significant if its inclusion decreases the log likelihood. The difference in log likelihood is Chi-squared distributed with 1 degree of freedom. (In general, the number of degrees of freedom equals the number of parameters in an unrestricted model, including random effects, that have to be set to zero to obtain the restricted model.) In the case at hand, not including p_{0i}, h_{0j} or c_{0ij} causes the value of the log likelihood to increase by 25, 47 and 2118, respectively. These increases are highly significant.

Table 4.1. Estimates of covariance parameters and intra-class correlations

	Estimates of model $FDI_{t(ij)} = b_{00} + p_{0i} + h_{0j} + e_{t(ij)}$	Estimates of model $FDI_{t(ij)} = b_{00} + p_{0i} + h_{0j} + c_{0ij}$
Level 1		
Individual variance, σ_e^2	85393849	25768340
Level 2		
Parent country variance, σ_{0p}^2	20392486	10502087
Host country variance, σ_{0h}^2	38130613	19750797
Parent-host combination variance, σ_{0ph}^2	-	62116747
Intra-class correlation		
Same parent country ($\sigma_{0p}^2/(\sigma_{0p}^2+\sigma_{0h}^2+\sigma_{0ph}^2+\sigma_e^2)$)		0.09
Same host country ($\sigma_{0h}^2/(\sigma_{0p}^2+\sigma_{0h}^2+\sigma_{0ph}^2+\sigma_e^2)$)		0.17
Same parent / host combination $((\sigma_{0p}^2+\sigma_{0h}^2+\sigma_{0ph}^2)/(\sigma_{0p}^2+\sigma_{0h}^2+\sigma_{0ph}^2+\sigma_e^2))$		0.78
$-2LL$	29423	27305

Dependent variable: $FDI_{t(ij)}$.

We conclude that intra-class correlation is a serious issue in these data that needs to be taken into account in order to make correct inferences. OLS neglects this clustering of observations and may thus lead to an overestimation (underestimation) of the coefficients' significance levels (standard errors). The higher is the correlations between observations from any of the three groups, the greater the bias in the estimated standard errors from OLS.

Table 4.2 demonstrates the effects of re-estimating the knowledge-capital model with the BDH data set using different estimation methods. Column (1) reproduces the BDH results using OLS. Most coefficients are statistically significant. $TCH_{t(j)}$ is the exception. Columns (2) – (4) in Table 4.2 present the results of OLS estimates with cluster-robust standard errors. The table presents the results of clustering by parent and host country and by country pair. As expected, the t-values decrease across the board.

Table 4.2. Estimation results BDH data set (N=2460)

	OLS (BDH)	Cluster-robust standard errors			Cross-class. multilevel model		Fixed effects
		Parent	Host	Country pair	Parent, host and p-by-h interaction		
$SUMGDP_{t(ij)}$	9.28***	9.28***	9.28**	9.28***	20.48***	19.15***	21.54***
	(25.88)	(4.75)	(2.33)	(4.09)	(25.97)	(25.19)	(19.68)
$(GDPDIFF_{t(ij)})^2$	–0.0007***	–0.0007*	–0.0007	–0.0007	–0.002***	–0.001***	–0.001***
	(7.22)	(2.03)	(1.03)	(1.43)	(10.43)	(9.63)	(5.85)
$SKDIFF_{t(ij)}$	272.47**	272. 47	272. 47	272. 47	3,039.60***	2,383.15***	4,135.55***
	(2.56)	(1.31)	(1.08)	(1.38)	(3.69)	(4.64)	(3.72)
$GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$	–0.69***	–0.69***	–0.69*	–0.69*	–1.25***	–1.28***	–1.78***
	(10.76)	(3.63)	(1.92)	(1.94)	(9.28)	(9.53)	(4.64)
$INVC_{t(j)}$	–46.21**	–46.21	–46.21	–46.21	153.73***	240.62***	221.30***
	(2.27)	(1.16)	(0.58)	(1.01)	(4.67)	(6.50)	(4.54)
$TCH_{t(j)}$	–4.14	–4.14	–4.14	–4.14	2.69	9.91	–13.18
	(0.92)	(0.61)	(0.34)	(0.50)	(0.26)	(0.75)	(0.63)
$TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2$	–1.38***	–1.38**	–1.38	–1.38*	2.27***	1.98***	4.42***
	(4.78)	(2.94)	(1.19)	(1.95)	(4.04)	(3.39)	(4.13)
$TCP_{t(i)}$	–69.86***	–69. 86**	–69. 86	–69. 86**	–21.15	10.17	40.62
	(5.95)	(2.25)	(1.50)	(2.44)	(0.82)	(0.37)	(1.09)
$DIST_{ij}$	–0.25***	–0.25*	–0.25*	–0.25*	–0.46***	–0.48***	
	(5.74)	(1.73)	(1.77)	(1.90)	(3.76)	(4.11)	
Intercept	726.46	726. 46	726. 46	726. 46	5,485.82	–18,041.30***	–37,289.93***
	(0.77)	(0.27)	(0.19)	(0.28)	(0.42)	(6.38)	(4.11)
Adjusted R^2	0.37	0.37	0.37	0.37			
Log likelihood	–25,981				–24,580	–24,617	–24,497

Absolute t-statistics in parentheses. The coefficients in columns (5) – (7) relate to within-country (parent-host combination) changes. Cluster means are included in columns (5) and (6) to ensure consistent estimators (not shown). The following means were included in column (5): *SUMGDP* by parent and host country, $GDPDIFF^2$ by host, *SKDIFF* by parent and host country, $GDPDIFF \times SKDIFF$ by host, *INVCH* by parent, *TCP* by host, *TCH* by parent, $TCH \times SKDIFF^2$ by host, and *DIST* by parent and host country. Column (6) includes only the means of *SKDIFF* by parent and $TCH \times SKDIFF^2$ by host.

The values in columns (2) – (4) appropriately reflect that there is less independence in the data than is implicitly assumed by the OLS procedure. Skill differences $SKDIFF_{t(ij)}$ and investment costs in the host country $INVC_{t(j)}$ are no longer statistically significant with clustering either by parent country, host country or country pair. The variables $GDPDIFF_{t(ij)}{}^2$, $TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2$ and $TCP_{t(i)}$ become insignificant with clustering by host country. $GDPDIFF_{t(ij)}{}^2$ is also insignificant with clustering by country pair.

Specifications (5) and (6) in Table 4.2 present the results for the cross-classified multilevel model with parent, host, and parent-by-host random effects. Specification (5) includes as many cluster means (parent and host-country and parent-host-combination) as possible. Specification (6) contains only the two statistically significant cluster means. Note that the interpretation of the coefficients in the multilevel regression is different from OLS: the multilevel results focus on the *within*-country and *within*-parent-host-combination changes instead of cross-country-level and cross-combination-level differences. The random effects entail using country- and parent-host-combination-specific means of 1982–1992 FDI stocks (see the explanation relating to equation (4.3)). The interpretation of the intercept in the multilevel model also changes compared to OLS. The results in the multilevel specifications reflect the expected amount of FDI invested by a randomly selected parent country in a randomly selected host country, in a randomly selected year. The random effects capture the deviations of parent i and host j and parent-host combination ij from this overall intercept.

The results in column (5) illustrate that taking account of clustering of FDI within parent and host countries and parent-host combinations and looking at the within-country and within-parent-host-combination changes makes a difference. First, coefficient sizes from the multilevel estimation are quite different from OLS. Most notable is the big increase in the coefficient of the skill-difference term vis-à-vis the coefficient from OLS.[80] This indicates that the impact of skill differences on FDI is particularly large for parent i and host j *over time*.[81] In addition, the coefficients on $INVCH_{t(j)}$, ($TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2$) and $TCH_{t(j)}$ change sign. Concerning investment costs we find that a higher level of investment costs in one host country versus another will increase the level of investment in the latter (results from OLS). However, an increase in investment costs within one host country *over time* does not have this effect (multilevel), even though as CMM (p. 702) point out “the theoretical results [should] apply equally well to time-series

[80] On account of the size of the coefficients in general, note that the regression of the knowledge-capital model is specified as linear in levels as opposed to log linear. Hence, different from common procedure in, e.g., the gravity literature, the coefficients do not represent elasticities. This explains the large absolute size of some of the coefficients (e.g., on the skill-difference term).

[81] The partial derivative of FDI with respect to skill differences is $b_3+b_4 \times GDPDIFF_{t(ij)}+2 \times b_7 \times TCH_{t(j)} \times SKDIFF_{t(ij)}$ (see below). Using the coefficients in column (5) of Table 3, a marginal increase in skill differences for a pair of countries, that are equal in size and with zero trade costs in the host country, increases FDI between them by 3,039 million U.S. dollars.

and cross-section processes". As for the remaining variables, the multilevel results are qualitatively similar to their OLS counterparts.

Column (6) presents the results from the specification with only two (statistically significant) cluster means. Although the results in this specification are *qualitatively* similar to those in (5) (only $TCP_{t(i)}$ changes sign), the coefficient sizes differ. This illustrates that, if one includes (too) few cluster means, the within-regression coefficients may incorporate (part of) the between-cluster effects (cf. Snijders and Berkhof, 2008).

Column (7) presents the results from the estimation of the knowledge-capital model with country and pair wise fixed effects. That is, the specification includes country (parent and host) and parent-host-combination dummy variables. This specification too, focuses on the within-country and within-parent-host-combination effects. Because distance is constant, this variable has to be dropped with (time-invariant) fixed effects. Summing up the evidence in specification (7), we find that the results with fixed effects estimation are largely consistent with the results from the multilevel analysis. Parameters by and large have similar signs and magnitudes.[82] Similar to the multilevel results (columns (5) and (6)) the coefficient of $INVCH_{t(j)}$ is positive with fixed effects. The sign reversal of the multilevel estimate of $TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2$ vis-à-vis OLS is equally mirrored by the fixed effects estimation.

We also ran the estimations using the CMM indicators of skilled-labour abundance, and trade and investment costs. Table 4.3 presents the results. Again, we find that the sizes of coefficients in the multilevel estimation (columns (5) and (6)) differ substantially from OLS and that there are even sign reversals (in this case, for $INVCH_{t(j)}$, $TCH_{t(j)}$, and $TCP_{t(i)}$).[83] The multilevel coefficient of $TCP_{t(i)}$ is consistent with the theoretical predictions of the knowledge-capital model, whereas the multilevel coefficient of $INVCH_{t(j)}$ is not consistent with the theory (cf. the results with the BDH indicators). The sign reversals in the multilevel regression vis-à-vis OLS of $INVCH_{t(j)}$ and $TCP_{t(i)}$ are again mirrored by results from the fixed effects estimation (specification (7)).[84]

[82] $TCH_{t(j)}$ and $TCP_{t(i)}$ are the main exceptions. These variables are statistically insignificant in all three specifications, though. In other words, the confidence intervals wrap around zero.
[83] The differences between specifications (5) and (6) in Table 4.3 are smaller than in Table 4.2. In fact, there is less multicollinearity in the multilevel regressions that include cluster means with the CMM indicators. Hence, more cluster means are retained in specification (6) in Table 4.3 compared to Table 4.2 (the regressions with the BDH indicators).
[84] The coefficient of $TCH_{t(j)}$ differs across the multilevel and the fixed effects estimation methods. Yet, it is highly insignificant statistically with either method.

Table 4.3. Estimation results, CMM indicators of skills, trade and investment costs (N=1474)

	OLS	Cluster-robust standard errors			Cross-class. multilevel model		Fixed effects
		Parent	Host	Country pair	Parent, host and p-by-h interaction		
$SUMGDP_{t(ij)}$	11.89***	11.89***	11.89**	11.89***	29.87***	29.85***	30.35***
	(26.48)	(4.95)	(2.33)	(4.19)	(22.66)	(22.83)	(11.68)
$(GDPDIFF_{t(ij)})^2$	–0.0016***	–0.0016**	–0.0016	–0. 0016**	–0.003***	–0.003***	–0.003***
	(13.55)	(2.69)	(1.55)	(2.52)	(13.50)	(13.62)	(6.20)
$SKDIFF_{t(ij)}$	10,340.10***	10,340.10*	10,340.10	10,340.10	18,373.01	24,350.82***	13,927.40
	(3.56)	(2.08)	(0.98)	(1.43)	(1.66)	(2.68)	(0.74)
$GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$	–13.40***	–13.40	–13.40*	–13.40	–13.69***	–14.07***	3.34
	(7.22)	(1.71)	(1.96)	(1.26)	(4.32)	(4.46)	(0.36)
$INVC_{t(j)}$	–255.18***	–255.18**	–255.18**	–255.18***	97.88***	100.80***	107.22**
	(6.73)	(3.01)	(2.24)	(3.89)	(3.12)	(3.22)	(2.01)
$TCH_{t(j)}$	64.13*	64.13	64.13	64.13	–5.84	–5.74	1.36
	(1.89)	(1.36)	(0.79)	(1.19)	(0.31)	(0.31)	(0.04)
$TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2$	–795.65*	–795.65*	–795.65	–795.65	–1,676.59***	–1,688.66***	–1,913.23*
	(1.78)	(1.87)	(1.09)	(1.25)	(2.99)	(3.02)	(1.73)
$TCP_{t(i)}$	18.41	18.41	18.41	18.41	–44.15**	–43.67**	–50.28
	(0.60)	(0.40)	(0.37)	(0.30)	(2.19)	(2.17)	(1.55)
$DIST_{ij}$	–0.49***	–0.49**	–0.49**	–0.49***	–0.55***	–0.53***	
	(7.95)	(2.84)	(2.72)	(2.86)	(3.64)	(3.58)	
Intercept	2,178.13	2,178.13	2,178.13	2,178.13	53,692.63**	19,866.46***	–5,027.41
	(1.46)	(1.07)	(0.66)	(0.76)	(2.13)	(6.11)	(0.81)
Adjusted R^2	0.44	0.43	0.43	0.43			
log likelihood	–15,743				–14,635	–14,637	–14,777

Absolute t-statistics in parentheses. The coefficients in columns (5) – (7) relate to within-country (parent-host combination) changes. Cluster means are included in columns (5) and (6) to ensure consistent estimators (not shown). The following means were included in column (5): *SUMGDP* by parent and host country, *SKDIFF* by parent and host country, $GDPDIFF \times SKDIFF$ by host, *INVCH* by parent, *TCH* by parent, $TCH \times SKDIFF^2$ by parent, and *DIST* by parent and host country. Column (6) includes only the means of *SUMGDP* by parent and host country, *SKDIFF* by host, $GDPDIFF \times SKDIFF$ by host and *DIST* by host.

4.5. Interpretation of the coefficients

A distinctive feature of the knowledge-capital model is that the effects on FDI due to a change in GDP differences, skill differences and trade costs of the host are not monotonous. This is the result of the interaction terms used in the knowledge-capital model. It implies that effects of the independent variables are different for different types of countries.

The partial derivative of FDI with respect to GDP differences, skill differences and host-country trade costs is $2\times b_2\times GDPDIFF_{t(ij)}+ b_4\times SKDIFF_{t(ij)}$, $b_3+b_4\times GDPDIFF_{t(ij)}+2\times b_7\times TCH_{t(j)}\times SKDIFF_{t(ij)}$ and $b_6+b_7\times SKDIFF_{t(ij)}{}^2$, respectively. It follows that the effect on FDI resulting from a change in, e.g., parent-country GDP vis-à-vis the host country, varies according to the differences between the two countries in GDP and skilled-labour abundance. The first column in Table 4.4 gives these partial derivatives using the estimated coefficients from Tables 4.2 and 4.3.[85]

Consider the impact on FDI of GDP differences first (panel A in Table 4.4). The *OLS derivatives* in column (1) of Table 4.4 indicate that the impact of GDP differences on FDI switches from negative to positive for smaller values of *GDPDIFF* and *SKDIFF*. This can be illustrated as follows. If the parent country is large (*GDPDIFF* > 0), an increase in parent-country GDP ($\Delta GDPDIFF > 0$) will decrease FDI for zero skill differences. The negative effect of an increase in parent-country GDP, when the parent is large, is further reinforced by large skill differences (*SKDIFF* > 0). To put it in a different way, if the parent is relatively skilled-labour abundant as well, an increase in parent-country GDP will reduce FDI for lower levels of GDP differences. On the other hand, if the parent is small (*GDPDIFF* < 0) and/or relatively skilled-labour scarce (*SKDIFF* < 0), an increase in parent-country GDP will increase FDI abroad. In this case, the increase in parent-country GDP implies income convergence. The effect of income convergence also works in the opposite direction: when a parent country is large, an increase in the *host*-country's GDP ($\Delta GDPDIFF < 0$) will increase FDI from parent i to host j. Columns (2) through (5) in Table 4.4 illustrate this numerically. We use the maximum values of *GDPDIFF* and *SKDIFF* in the sample to express that the parent is large and skill-abundant relative to the host, and the minimum value of *GDPDIFF* and *SKDIFF* (both of which < 0) as a proxy for a small (large) and relatively skilled-labour scarce (abundant) parent (host).[86]

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[85] Concerning the multilevel derivatives, we employed the coefficients in column (5) of Tables 4.2 and 4.3.

[86] In the calculation of the partial derivatives in Table 4.4, we always use the maximum or minimum value for only one variable, whilst fixing the other variable(s) in the expression to its sample mean. The values used in the calculations are given in Appendix 4A.

Table 4.4. Impact of GDP differences, skill differences and host-country trade costs on FDI

(1)	(2)	(3)	(4)	(5)
A. Impact of GDP differences [a]	Minimum *GDPDIFF*	Maximum *GDPDIFF*	Minimum *SKDIFF*	Maximum *SKDIFF*
OLS Table 3: $-0.0007 \times 2 \times GDPDIFF_{t(ij)} - 0.69 \times SKDIFF_{t(ij)}$	5.26	–7.50	2.79	–6.52
OLS Table 4: $-0.002 \times 2 \times GDPDIFF_{t(ij)} - 13.4 \times SKDIFF_{t(ij)}$	13.91	–15.07	1.62	–5.75
Multilevel Table 3: $-0.002 \times 2 \times GDPDIFF_{t(ij)} - 1.25 \times SKDIFF_{t(ij)}$	16.23	–20.23	4.09	–12.79
multilevel Table 4: $-0.003 \times 2 \times GDPDIFF_{t(ij)} - 13.7 \times SKDIFF_{t(ij)}$	26.54	–27.80	0.07	–7.46
B. Impact of skill differences [a]	Minimum *GDPDIFF*	Maximum *GDPDIFF*	Minimum *SKDIFF*	Maximum *SKDIFF*
OLS Table 3: $272.5 - 0.69 \times GDPDIFF_{t(ij)} - 1.38 \times 2 \times TCH_{t(j)} \times SKDIFF_{t(ij)}$	3,285	–3,004	279	–887
OLS Table 4: $10{,}340 - 13.4 \times GDPDIFF_{t(ij)} - 796 \times 2 \times TCH_{t(j)} \times SKDIFF_{t(ij)}$	68,638	–52,729	16,893	–13,477
Multilevel Table 3: $3{,}040 - 1.25 \times GDPDIFF_{t(ij)} + 2.27 \times 2 \times TCH_{t(j)} \times SKDIFF_{t(ij)}$	8,990	–2,403	1,440	3,358
Multilevel Table 4: $18{,}373 - 13.7 \times GDPDIFF_{t(ij)} - 1{,}677 \times 2 \times TCH_{t(j)} \times SKDIFF_{t(ij)}$	75,535	–48,458	40,653	–23,343
C. Impact of host-country trade costs	Minimum $SKDIFF^2$	Maximum $SKDIFF^2$		
OLS Table 3: $-4.14 - 1.38 \times SKDIFF_{t(ij)}^{2}$	–4.14	–94.68		
OLS Table 4: $64.1 - 796 \times SKDIFF_{t(ij)}^{2}$	64.13	–2.78		
Multilevel Table 3: $2.69 + 2.27 \times SKDIFF_{t(ij)}^{2}$	2.69	151.62		
Multilevel Table 4: $-5.84 - 1{,}677 \times SKDIFF_{t(ij)}^{2}$	–5.84	–146.84		

[a] The derivatives are calculated by fixing, one at a time, *GDPDIFF* and *SKDIFF* to their maximum and minimum value in the sample (see Appendix 4A), whilst fixing the other variable(s) in the expression to the sample mean.
To calculate the multilevel derivatives, we employed the coefficients in column (5) of Tables 4.2 and 4.3. Table 4.2 uses the BDH indicators, Table 4.3 the CMM indicators for skilled-labour abundance and trade and investment costs.

Second, concerning the impact of differences in skill endowments (panel B in Table 4.4), the OLS derivatives indicate that an increase in the skilled-labour abundance of the parent has a positive effect on FDI when countries are similar, or when the parent is relatively small or skilled-labour scarce (*GDPDIFF* and *SKDIFF* < 0). Larger GDP and/or skill differences reduce this effect. That is, when the parent is large and/or skilled-labour abundant relative to a host, an increase in skill abundance of the parent will reduce its FDI abroad. In this case, FDI will rather increase as a result of an increase in the skilled-labour abundance of the *host* country ($\Delta SKDIFF < 0$). This result implies that FDI from large and skill abundant countries is attracted to more skilled-labour abundant host countries. CMM find similar results based on bilateral FDI for the U.S. CMM conclude that this result is "consistent with the well-known stylised fact that the poorest countries in the world receive a much smaller share of world investment than their share of world income" (p. 706). Our results for the OLS derivatives are consistent with the empirical findings, as well as the predictions from theory and the simulations in the original paper by CMM.

Next, consider the multilevel derivatives in panels A and B in Table 4.4. The multilevel derivatives express the effects of the explanatory variables on FDI *over time*. The results in Table 4.4 indicate that the effects of GDP differences and relative endowment differences on FDI over time are qualitatively similar to the country/temporal effects from OLS. An increase in parent-country GDP over time vis-à-vis the host will increase FDI if the parent is small (*GDPDIFF* < 0) and/or more skilled-labour *scarce* (*SKDIFF* < 0), and decrease FDI if the parent country is large and/or more skilled-labour abundant. Similarly, the multilevel derivatives also suggest that an increase over time in the skilled-labour abundance of the parent will reduce FDI from the parent if the parent is relatively large and/or skill abundant, whilst an increase in host-country skill abundance will increase FDI from the parent to the host in that case.[87] Hence, the effects of GDP differences and relative endowment differences on FDI apply across countries and over time.

Panel C of Table 4.4 gives the results for the impact of host-country trade costs. The results are mixed. They differ across estimation methods and, with the same estimation method, across indicator sets. This is due to the fact that the coefficient of $TCH_{t(j)}$ is positive on one occasion and negative on the next. So, we cannot draw any firm conclusions as to the effect of host-country trade costs on FDI, across countries nor over time.

[87] In the multilevel derivative using the BDH indicators, the coefficient $b_7 > 0$. In this case, the change in the effect of a difference in skill endowments from positive to negative does not depend on *SKDIFF*. Nevertheless, the results that an increase in the skilled-labour abundance of the parent ($\Delta SKDIFF > 0$) over time may reduce FDI from the parent if the parent is relatively large and that an increase in the skilled-labour abundance of the host country ($\Delta SKDIFF < 0$) may increase inward investment if this host is small relative to the parent apply here too. The term *GDPDIFF* is dominant in the derivative.

4.6. Conclusion

The data used in Part II of this study involve a panel data set with multiple parent and host countries. The use of panel data has become increasingly prominent in the empirical literature (see, e.g., Baltagi, 1995, Hsiao, 2003, Verbeek, 2004). The use of a panel data set will generally yield more efficient estimators than cross-sectional or time series data because data vary over two dimensions, countries and time. Also, with panel data, one can control for time invariant country-specific effects (e.g., Egger, 2000). An issue that often remains unaddressed in the literature is the clustering of observations in a panel data set: because the same units are repeatedly observed, it may no longer be appropriate to assume that observations are independent. In particular, if the time-series variation in the data is weak, the closer one is to merely running a series of cross-section regressions. The estimated standard errors from OLS, which assume independence of observations, will be biased accordingly. In the empirical analysis of bilateral phenomena such as international trade, FDI, migration, etc., with panel data, the issue of clustering is particularly complex since there are several repeated observations: for countries of origin (over all destination countries), for destination countries (over all origin countries), for origin and destination countries over time, and for specific origin-destination combinations.

This chapter holds relevant lessons for empirical investigations of bilateral trade, FDI, migration, etc., with panel data. The chapter illustrates that multilevel analysis offers a useful framework to address intra-class correlation when there are several cluster variables at the same time. We use a cross-classified multilevel technique to account for clustering of FDI within parent and host countries and parent-host combinations. The general idea of the multilevel analysis in this study is first that higher-level (here, parent, host or parent-host-combination) heterogeneity has an impact on the dependent variable. Next, that because of these higher-level effects, 'years' (annual FDI values) for the same parent country i, host country j, or the same parent-host combination tend to be more alike. The multilevel model therefore accounts for the effects of parent, host or parent-host-combination heterogeneity on FDI and subsequently explains the variance between years for parent country i and host j. The advantage of the cross-classified multilevel model over cluster-robust linear regression in this study is that the former accounts for three cluster variables simultaneously. With cluster-robust linear regression one can only use one cluster variable (host, parent or combination) at a time.

Contrary to common practice in the gravity literature, the cross-classified multilevel model uses random rather than fixed effects for controlling for the effects of parent, host and parent-host-combination heterogeneity. A possible drawback of random effects is the correlation between the random effects and the explanatory variables. This chapter shows that unbiased estimates can equally be obtained with random effects, provided that the cluster means of the explanatory variables are added to the model.

This chapter fits a cross-classified multilevel version of the knowledge-capital model to the FDI data of the OECD. The multilevel approach entails estimating the effect of the explanatory variables *over time* for parent *i* and host *j*. We find that, for the most part, the predictions of the knowledge-capital model as derived from theory and simulations (see CMM) equally apply over time. That is, coefficient sizes from the multilevel estimation are different from OLS, yet the effects of the explanatory variables on FDI over time are qualitatively similar to the country/temporal effects from OLS. Summing up, the results indicate that FDI between two countries increases in the sum of their GDPs. Convergence in income between two countries increases FDI from parent *i* to host *j* in both directions. In other words, both size and similarity between countries in terms of size are important for FDI. These findings are consistent with the predictions of the knowledge-capital model regarding horizontal FDI. Economies of scale to a large extent explain the need for size (in both markets) in this type of FDI. Third, an increase in the skilled-labour abundance of the parent will increase FDI if the parent is relatively small and/or skilled-labour scarce. On the other hand, when the parent is large and/or relatively skill abundant, an increase in *host*-country skill abundance will increase FDI from the parent to the host. The latter indicates that FDI from large and skill abundant OECD countries is attracted to more skill-abundant hosts. Here, we find an explanation for the stylised fact that FDI is foremost between developed, high-income countries. Concerning investment costs we find that, on the one hand, a higher level of investment costs in one host country versus another increases the level of investment in the latter (OLS-results and consistent with theoretical prediction). However, an increase in investment costs within one host country over time does not have this effect (multilevel). The results concerning the impact over time of trade costs of the host country are inconclusive. The theoretical prediction is that high trade costs in a host country induce horizontal FDI as a substitute for exports. Yet, our results differ across the indicator sets.

The distinctive feature of the knowledge-capital model is that, within aggregate FDI, it distinguishes between horizontal and vertical FDI. To capture the distinction between horizontal and vertical FDI, the empirical specification in CMM imposes a certain structure on the data. In particular, to capture the predictions of the vertical model, the specification: (i) imposes the subtractive linear constraint that the coefficients on parent and host country skilled-labour abundance are of equal size but opposite in sign; and (ii) includes the interaction between income differences and skill differences. To allow for such interaction terms, CMM do not log the data, but use a linear specification instead. The empirical specification of the knowledge-capital is derived from theory. Yet, to what extent do the data support such a structure? We investigate this question in the next chapter.

Appendix 4A. Data

Table 4A.1 gives the descriptive statistics for the sample with the BDH indicators.

Table 4A.1 – Summary statistics for sample with BDH indicators (*N*=2460)

Variable	Mean	Standard deviation	Minimum	Maximum
$FDI_{t(ij)}$	4,322	11,762	–357.1	176,781
$SUMGDP_{t(ij)}$	1,674	1,498	73.0	6,449
$GDPDIFF_{t(ij)}^2$	3.2e+06	5.8e+06	1.2e-04	2.1e+07
$SKDIFF_{t(ij)}$	1.65	2.69	–5.40	8.1
$GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$	3,401	6,460	–6,996	31,012
$INVC_{t(j)}$	42.0	12.3	17.3	65
$TCH_{t(j)}$	31.3	59.3	–286.2	87.3
$TCH_{t(j)} \times SKDIFF_{t(ij)}^2$	422.6	1,050	–6,559	5,599
$TCP_{t(i)}$	52.0	22.3	–18.8	82.4
$DIST_{ij}$	6,303	4,792	174	18,372

Table 4A.2 gives the descriptive statistics for the sample with the CMM indicators.

Table 4A.2 – Summary statistics for sample with Carr et al. indicators (*N*=1474)

Variable	Mean	Standard deviation	Minimum	Maximum
$FDI_{t(ij)}$	5290.5	14049.9	–357.1	176,781
$SUMGDP_{t(ij)}$	1591.1	1539.2	88.6	6,449
$GDPDIFF_{t(ij)}^2$	3.2e+06	6.1e+06	0.004	2.1e+07
$SKDIFF_{t(ij)}$	0.04	0.12	–0.26	0.29
$GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$	57.4	211.6	–297. 8	1,086.8
$INVC_{t(j)}$	38.3	11.3	14. 9	68.3
$TCH_{t(j)}$	34.7	12.4	7.86	81.4
$TCH_{t(j)} \times SKDIFF_{t(ij)}^2$	0.56	0.76	0	5.50
$TCP_{t(i)}$	34.3	9.46	14.3	56.6
$DIST_{ij}$	6,111	4,963	174	18,837

Appendix 4B. Basic ideas of multilevel analysis through a simple illustration

In this appendix we explain the basic ideas of multilevel analysis through a simple illustration.

4B.1. Hierarchical data

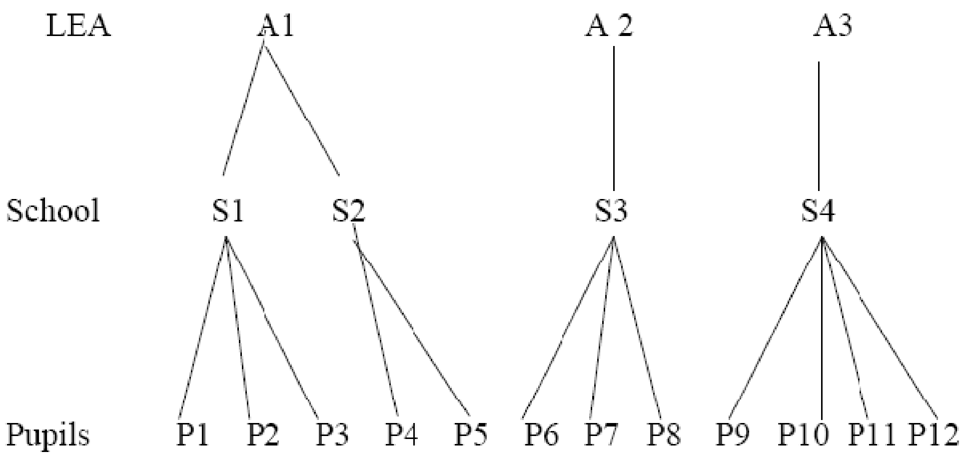
In social science research data are often hierarchical. Consider, e.g., a population consisting of schools and pupils within these schools. In this example, pupils (level 1) are clustered, or nested, within schools (level 2). In addition, schools may be nested in an even higher level like districts or countries. This is an example of a strict hierarchy (see Figure 4B.1 panel (a)). Data structures need not always be a strict hierarchy as in the previous example. Cross-classified data are examples of non-hierarchical multilevel data. Cross classifications exist when several higher-level units exist next to each other. For instance, pupils (level 1) are nested within schools and areas, which are two parallel level-2 units (see Figure 4B.1 panel (b)).

4B.2. Multilevel analysis

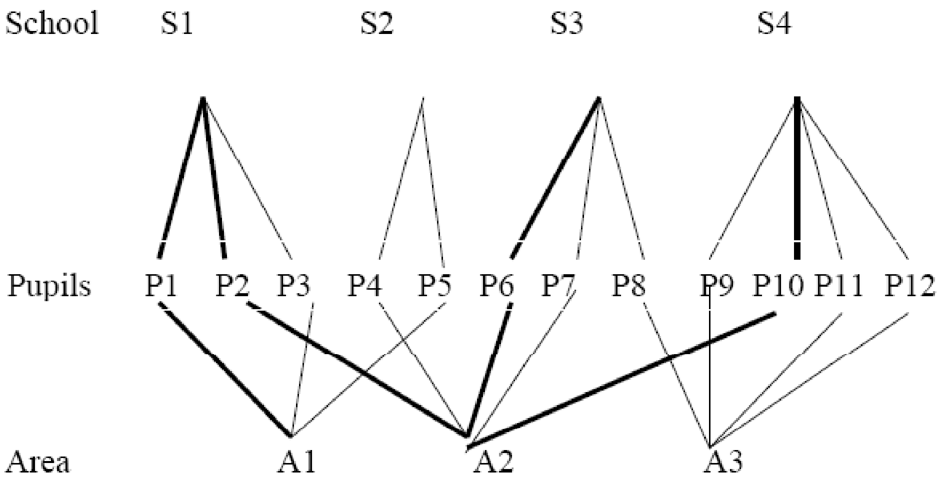
Each level of the hierarchy, from pupils at the first level to schools and areas at level 2, or school districts at the highest level, can conceivably contribute to variation in the level-1 dependent variable, pupils' school performance (Houchens et al., 2007). In other words, there may be influential 'school, area or district effects' which are every bit as important in explaining the variation in pupils' school performance as the characteristics of the children. If the effects of school (and in more complex structures the effects of, e.g., area or district) are strong, children from the same school etc., will tend to be more like each other than pupils chosen at random from the population of children at large (Fielding and Goldstein, 2006). An analysis that takes higher-level effects into account is clearly desirable in these examples.

Multilevel models are an appropriate way of handling hierarchical data structures (see, e.g., Snijders and Bosker, 1999, Hox, 2002, Fielding and Goldstein, 2006). Multilevel models model (the different sources of) variability at each level of the hierarchy and properly adjust estimates to account for them (Houchens et al., 2007).

Figure 4B.1 – Illustrations of multilevel data structures



Panel (a). Three-level structure of pupils within schools within Local Education Authorities (districts)



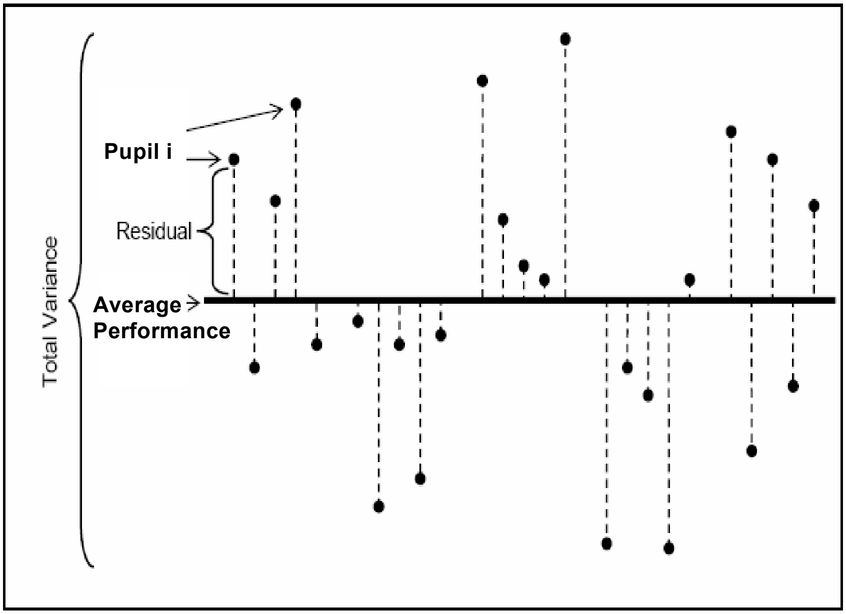
Panel (b). Pupils at level 1 nested within a school and an area cross-classified at level 2

Source: Fielding and Goldstein (2006).

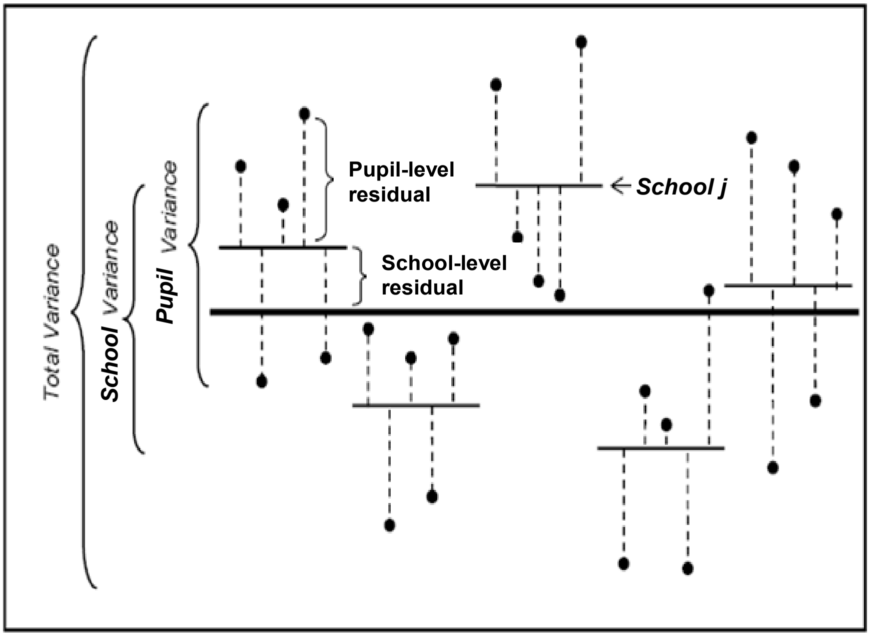
Let's illustrate the basic ideas of multilevel analysis by keeping with the example of pupils' school performance. Figure 4B.2 graphically displays variation in pupils' school performance for a simple two-level hierarchy of pupils and schools, not including any explanatory variables.

Panel (a) illustrates the variation in pupils' school performance without accounting for clustering. The variation in pupils' performance is accounted for in its entirety by the deviation of individual pupils' performance from the average (the residuals).

Figure 4B.2 – Sources of variation in a simple hierarchy of pupils and school



Panel (a). Single level ignoring clustering



Panel (b). Two-level taking into account clustering

Source: adapted from Houchens et al. (2007)

In a more formal way, the situation represented by Figure 4B.2(a) can be written as:

$$y_i = \beta_0 + e_i. \tag{4B.1}$$

In equation (4B.1), β_0 is the mean school performance across all pupils; e_i represents the individual residual for pupil i, i.e. the deviation of school performance of pupil i from the overall mean β_0, where $e_i \sim N(0, \sigma_e^2)$.

Panel (b) in Figure 4B.2(b) gives the same data but taking into account clustering. The total variation in pupils' performance is now the sum of school variance and pupil variance. The school variance is represented by the spread of the school-level residuals around the overall mean. The pupil variance is represented by the spread of the pupil-level residuals around the school means.

A corresponding model of Figure 4B.2(b) can be written as:

$$y_{ij} = \beta_{0j} + e_{ij}, \tag{4B.2}$$

where, y_{ij} denotes school performance of pupil i in school j. β_{0j} represents the mean of the dependent variable for school j. e_{ij} represents the deviation of school performance of pupil i in school j from the mean value β_{0j} for school j. $e_{ij} \sim N(0, \sigma_e^2)$.

In (4B.2) we have a model where β_{0j} has a subscript relating to a particular school j rather than β_0. β_{0j} is typically assumed to vary randomly across schools:

$$\beta_{0j} = \beta_{00} + u_{0j}. \tag{4B.3}$$

In equation (4B.3), β_{00} is the grand mean, i.e., the expected school performance of a randomly selected pupil i in a randomly selected school j. u_{0j} is the deviation of school j from grand mean β_{00}, where $u_{0j} \sim N(0, \sigma_{u0j}^2)$ and $\beta_{00} + u_{0j}$ is the mean school performance of pupils in school j.

By substituting equation (4B.3) in (4B.2), we obtain the following baseline model:

$$y_{ij} = \beta_{00} + u_{0j} + e_{ij}. \tag{4B.4}$$

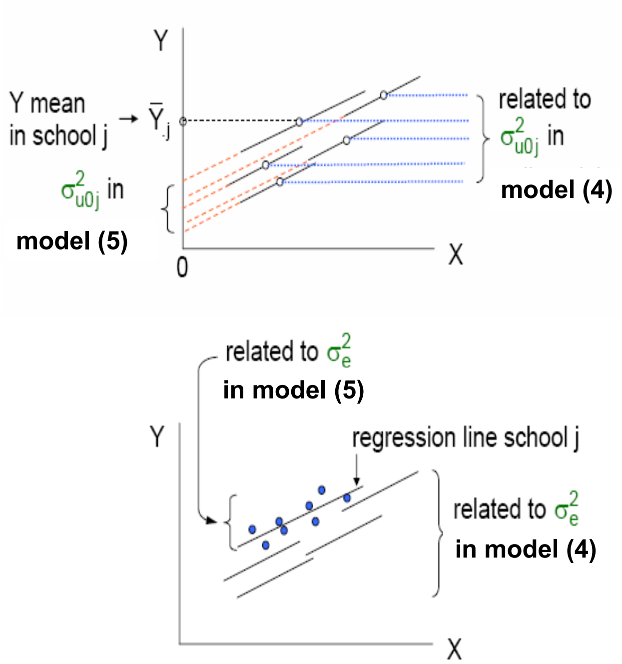
Model (4B.4) is often called a 'null', 'empty' or 'variance component' model. By adding to model (4B.4) explanatory variables we can explain the variance in y_{ij}. Let's – for the sake of graphical simplicity below – add only one explanatory variable, x_{1ij}. The multilevel model then becomes:

$$y_{ij} = \beta_{00} + u_{0j} + \beta_1 x_{1ij} + e_{ij}. \tag{4B.5}$$

The interpretation of β_{00} in model (4B.5) has, compared to model (4B.4), changed from 'grand mean' to 'grand intercept', with u_{0j} now being school deviations from this 'grand intercept'. Model (4B.5) is commonly called the 'random intercept' model.

Figure 4B.3 illustrates the different interpretations of the random parameters u_{0j} and e_{ij} in the baseline model (4B.4) and the 'full' multilevel model (4B.5).

Figure 4B.3 – Difference variance component model and random intercept model



The model in (4B.5) can be easily extended to include more random effects. Adding another level-2 effect (for l = 1, …, L areas) we get a cross-classified multilevel model comparable to the one we use in the main text:

$$y_{ijl} = \beta_{000} + u_{0j} + u_{0l} + \beta_1 x_{1ijl} + e_{ijl}\,. \tag{4B.6}$$

Multilevel models also allow slopes to be random:

$$y_{ij} = \beta_{00} + u_{0j} + \beta_1 x_{1ij} + u_{1j} x_{1ij} + e_{ij}\,. \tag{4B.7}$$

In model (4B.7) we have two random effects (u_{0j} and u_{1j}) at the school level. The relation between x_{1ij} and y_{ij} is now given by $\beta_{1j} = \beta_1 + u_{1j}$. In the context of our study, we have no theoretical reason to assume that the effects of the explanatory variables in the knowledge-capital model should be different for different country groups and combinations, so we do not pursue this route. But this serves to illustrate the flexibility of multilevel modelling.

Appendix 4C. Calculation of covariance

In this appendix we compare different ways to estimate the covariance matrix of the OLS estimator.

The true covariance matrix of the OLS estimator of β is: $V\{b\} = (X'X)^{-1}X'(\sigma^2 V)X(X'X)^{-1}$, where V is the covariance matrix of the random error term.

Under Gauss-Markov conditions $V=I_N$, where I_N is the identity matrix. Consequently, the covariance matrix of the OLS estimator of β is: $V\{b\} = \sigma^2 (X'X)^{-1}$. The variance of the OLS estimator b is routinely calculated as $\hat{\sigma}^2 (X'X)^{-1}$, where $\hat{\sigma}^2 = \frac{\sum \hat{e}^2_{t(ij)}}{N-k}$ is an unbiased estimator of σ^2.

In the cross-classified multilevel model in this paper, the off-diagonal components of the covariance matrix are not (necessarily) zero. We can illustrate the structure of the covariance matrix in our model by a simple example. Consider five observations of bilateral FDI with only two parent countries (i = 1, 2) and two host countries (j = 1, 2) as presented in Table 4C.1. The table indicates, e.g., that observations 1–3 are for the same host and that observations 1, 3 and 5 are for the same parent, and that observations 1 and 3 are for the same parent and host.

Using p, h, c and e to denote the variances σ^2_{0p}, σ^2_{0h}, σ^2_{0ph} and σ^2_e in the main text, the structure of the covariance matrix for these five observations is as follows:

Table 4C.1 – Five observations of bilateral FDI with 2 parents and 2 hosts

Observation	Parent (i)	Host (j)
1	1	1
2	2	1
3	1	1
4	2	2
5	1	2

$$V = \begin{pmatrix} p+h+c+e & h & p+h+c & 0 & p \\ h & p+h+c+e & h & p & 0 \\ p+h+c & h & p+h+c+e & 0 & p \\ 0 & p & 0 & p+h+c+e & h \\ p & 0 & p & h & p+h+c+e \end{pmatrix}$$

Cells (2,1) and (1,2), e.g., gives the covariance of observations 1 and 2. The matrix reflects, e.g., that observations 1 and 2 are for the same host (see Table 4C.1).

In this study, we use Maximum Likelihood to estimate the variance components. An alternative method is using Baysian estimation such as Monte Carlo Markov Chain (MCMC) estimation (Fielding and Goldstein, 2007).

Cluster-robust linear regression uses the following estimate of the variance of the OLS estimator: $\hat{V}_{Cluster} = (X'X)^{-1} \sum_{c=1}^{n_c} u_c' u_c (X'X)^{-1}$, where n_c is the total number of clusters. $u_c = \sum_c e_{t(ij)} x_{t(ij)}$. The formula for the clustered estimator is that of the heteroskedasticity-consistent (White) standard errors[88] with the individual $e_{t(ij)} x_{t(ij)}$'s replaced by their sum within each cluster.

[88] $\hat{V}_{Robust} = (X'X)^{-1} \left(\sum_{i=1}^{N} (e_{t(ij)} x_{t(ij)})' (e_{t(ij)} x_{t(ij)}) \right) (X'X)^{-1}$.

5

The Knowledge-Capital Model – Robustness Analysis

5.1. Introduction

The knowledge-capital model (Markusen et al., 1996, Markusen, 1997 and 2002) provides the most articulate general equilibrium model of MNE with proper microeconomic foundations. The distinctive feature of the knowledge-capital model is that, within aggregate FDI, it distinguishes between horizontal and vertical FDI. The gravity equation presents an alternative model to explain bilateral FDI. The gravity equation is the most commonly used model in the empirical literature to explain the variation in trade or investments flows between countries. It is only loosely connected to theory.

Compared to a standard gravity equation, the empirical specification of the knowledge-capital model is rather complex. The empirical specification in CMM (i) imposes linear constraints; and (ii) includes interactions of variables. To allow for such interaction terms, CMM do not log the data, but use a linear specification instead. The empirical specification of the knowledge-capital is derived from theory.

In this chapter we test the robustness of the empirical specification of the knowledge-capital model for the OECD data. We raise two questions. First, are the linear constraints imposed in the empirical specification supported by the data? And second, how appropriate is the functional form of the model? It turns out that the specification is not robust in the confrontation with data on bilateral FDI of the OECD. The subtractive linear restriction that parent and host-country skill abundances have equal but opposite effects on FDI, which serves to capture that differences in relative skill abundance give rise to vertical FDI, is rejected by the data. Also, a log linear specification is more appropriate. In the second part of the chapter we therefore estimate a gravity model of bilateral FDI. With respect to skilled labour we distinguish measures of human capital and skilled-labour abundance. We then extend the specification with GDP per capita and institutional quality.

The chapter is organised as follows. Section 5.2 tests the linear restrictions and the functional form of the knowledge-capital model for FDI data of the OECD. Section 5.3 presents the gravity model and discusses the results concerning the effect of skilled labour. We examine the robustness of the results for specifications that include GDP per capita and institutional quality as additional control variables. In Section 5.4 we estimate a cross-classified multilevel version of the gravity model to take into account intra-class correlation. Section 5.5 concludes.

5.2. The empirical specification of the knowledge-capital model

In this section we test the linear restrictions and the functional form of the knowledge-capital model for FDI data of the OECD. As explained in Chapter 3 (Section 3.6.6), we use the indicator set of BDH and the CMM indicators of skilled labour and trade and investment costs in the empirical analysis of the knowledge-capital model.

5.2.1. Testing the linear restrictions

The distinctive feature of the knowledge-capital model is that, within aggregate FDI, it distinguishes between horizontal and vertical FDI. As explained in Chapter 3, the model predicts that horizontal FDI is high when both countries are similar in size and large; vertical FDI is high when countries differ in relative skill abundance. The empirical specification imposes linear constraints on the coefficients on parent and host country GDP, and of parent and host country skilled-labour abundance. This is illustrated by equation (5.1). The model in equation (5.1) gives an unrestricted version of the model:

$$\begin{aligned} FDI_{ij} &= \beta_0 + \beta_1 GDP_{t(i)} + \beta_2 GDP_{t(j)} + \beta_3 (GDPDIFF_{t(ij)})^2 + \beta_4 SK_i + \\ &\beta_5 SK_{t(j)} + \beta_6 (GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}) + \beta_7 INVC_{t(j)} + \beta_8 TC_{t(j)} + \\ &\beta_9 (TC_{t(j)} \times SKDIFF_{t(ij)}^{\;2}) + \beta_{10} TC_{t(i)} + \beta_{11} DIST_{t(ij)} + \varepsilon_{t(ij)}. \end{aligned} \tag{5.1}$$

The empirical specification of the knowledge-capital model imposes the restriction that $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$.

The model is estimated using weighted least-squares (WLS). Figure 5B.1 in Appendix 5B.2 shows the residuals from estimating the knowledge-capital model for bilateral FDI of the OECD plotted against the fitted values (using the BDH indicators and the CMM indicators of skilled labour and trade and investment costs, respectively). The graphs indicate the clear presence of heteroskedasticity.[89] This implies that "routinely computed standard errors of the estimators are based on the wrong expression. Thus, standard *t*- and *F*-tests are no longer valid and inferences will be misleading" (Verbeek, 2004, p. 80). We assume heteroskedasticity of the form $\sigma_i^2 = \sigma^2 \exp\{z_i'\alpha\}$.[90] That is, we assume that the error variance is related to the explanatory variables of the knowledge-capital model, with z_i denoting the full set of explanatory variables.[91] The weights for the WLS estimation are then computed by $h_i^{-2} = \exp\{z_i'\alpha\}$.[92]

Table 5.1 presents the results of the WLS regressions. All coefficients have signs that are consistent with the predictions of the knowledge-capital model (see Chapter 3) and most of them are statistically significant. Different from the results with OLS (see Chapter 4), the variable ($GDPDIFF_{ij} \times SKDIFF_{ij}$) is no longer significant in the WLS regression with the BDH indicators, whilst the coefficient of host-country trade costs TCH_j is not significant in the regression with the CMM indicators of skilled-labour abundance and trade and investment costs.

Next we test the linear restrictions. We test the two restrictions individually (once in a model with the other restriction still imposed and once in a model without restrictions) and jointly, for the two sets of indicators. The results are given in Tables 5.2 and 5.3.

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[89] In Blonigen and Davies (2004), residuals from estimating the empirical specification of the knowledge-capital model in (5.1) "are far from white noise" (Blonigen, 2005, p. 27). Blonigen and Davies use the bilateral data for the U.S. like CMM, but for a more extended sample of countries (88 developed and less developed) and years (1980–1999). They add bilateral tax treaties.

[90] The exponential function is used to guarantee positivity of the error variance for all parameters (Verbeek, 2004).

[91] In Appendix 5B.1 we test the assumption of multiplicative heteroskedasticity and investigate what specification for the form of multiplicative heteroskedasticity is most appropriate.

[92] The parameters α can be consistently estimated by computing the log of the squared residuals of the OLS regressions (log e_i^2) and running a regression of log e_i^2 on z_i and a constant. The exponential of the predicted values from this auxiliary regression can be used as weights.

Table 5.1. Results WLS using different indicator sets

	(1)	(2)
$SUMGDP_{t(ij)}$	3.50***	4.30***
	(19.55)	(17.27)
$(GDPDIFF_{t(ij)})^2$	–0.0005***	–0.0005***
	(7.26)	(7.06)
$SKDIFF_{t(ij)}$	96.24***	6,660.31***
	(2.64)	(6.18)
$GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$	–0.05	–5.69***
	(1.28)	(4.97)
$DIST_{ij}$	–0.13***	–0.19***
	(9.38)	(8.25)
$INVC_{t(j)}$	–61.95***	–105.86***
	(10.60)	(8.77)
$TCH_{t(j)}$	0.10	20.18*
	(0.11)	(1.88)
$TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2$	–0.24**	–467.81***
	(2.33)	(3.08)
$TCP_{t(i)}$	–17.50***	–42.44***
	(4.98)	(4.20)
Constant	3,079.89***	4,860.42***
	(11.23)	(10.43)
Adjusted R^2	0.24	0.29
Observations	2460	1474

Absolute (robust) *t* statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5.2 indicates that, with the BDH indicators, imposing the restriction that $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$ at the same time is rejected in favour of an unrestricted model at the 5% significance level.[93] The table indicates that the restrictions do not hold when the other restriction is imposed. The results in Table 5.2 suggest that the data are slightly in favour of the constraint on the coefficients of skilled-labour abundance.[94]

[93] The critical value $F(2, \infty) = 2.99$.

[94] The hypothesis $\beta_1 = \beta_2$ is rejected. We find that $\beta_1 > \beta_2$, a result that is comparable to standard findings in the empirical literature on international trade and FDI.

Table 5.2. Testing restrictions. BDH indicators

H_0	Keeping the other linear restriction (on GDP or skills)		Unrestricted model	
	F-statistic	5%	*F*-statistic	5%
1. $\beta_1 = \beta_2$	$F(1, 2449) = 5.33$	Rejected	$F(1, 2448) = 3.79$	Not rejected
2. $\beta_4 = -\beta_5$	$F(1, 2449) = 4.46$	Rejected	$F(1, 2448) = 2.56$	Not rejected
Signs skill variables	$\beta_4 > 0$ $\beta_5 < 0$			
3. $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$			$F(2, 2448) = 3.49$	Rejected
Signs skill variables			$\beta_4 > 0$ $\beta_5 < 0$	

With the CMM indicators of skilled labour and trade and investment costs (Table 5.3), the null hypothesis that coefficients on parent and host country skilled-labour abundance are equal but opposite in sign is rejected both in the model with the restriction regarding the coefficients of parent and host-country GDP and without.[95] It follows that, whilst the WLS estimations in Table 5.1 confirm the theoretical predictions of the knowledge-capital model regarding skill differences, the hypothesis that $\beta_4 = -\beta_5$ is not supported empirically. The hypothesis that $\beta_1 = \beta_2$ is supported by the data.

Hence, we find that the linear restriction that parent and host-country skill abundances have equal but opposite effects on FDI is rejected for FDI of the OECD. This means that, while our estimations confirm the theoretical predictions of the knowledge-capital model that (vertical) FDI increases with skill differences, the restriction that is imposed to capture this effect is not supported empirically. A specification in which parent and host-country skilled labour are estimated separately seems more appropriate.

[95] Note that both coefficients are positive in a specification in which the aggregation constraint on parent and host-country GDP levels is imposed. The coefficient on host-country skill abundance statistically highly insignificant, though.

Table 5.3. Testing restrictions. CMM indicators of skills, trade and investment costs

H_0	Keeping the other linear restriction (on GDP or skills)		Specification without linear restrictions	
	F-statistic	5%	F-statistic	5%
1. $\beta_1 = \beta_2$	$F(1, 1463) = 2.04$	Not rejected	$F(1, 1462) = 0.44$	Not rejected
2. $\beta_4 = -\beta_5$	$F(1, 1463) = 55.16$	Rejected	$F(1, 1462) = 45.67$	Rejected
Signs skill variables	$\beta_4>0$ $\beta_5>0$			
3. $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$			$F(2, 1462) = 24.03$	Rejected
Signs skill variables			$\beta_4>0$ $\beta_5<0$	

5.2.2. Functional form

A reason for heteroskedasticity may be misspecification of the functional form (see, e.g., Verbeek, 2004). We can write the knowledge-capital model as $y = g(x) + \varepsilon$. It is also possible to consider a multiplicative model, $y = g(x)\exp\{\eta\}$. If $\varepsilon = g(x)[\exp\{\eta\}-1]$, the two models are equivalent. If η is homoskedastic it follows that ε is heteroskedastic with a variance depending on $g(x)$. Thus, if we find heteroskedasticity in an additive model it could be the case that a multiplicative model is more appropriate. The multiplicative model can be written as an additive model by taking logarithms. This gives $\log y = \log g(x) + \eta = f(x) + \eta$. The function f typically involves the logs of the x-variables.

Considering a loglinear model is actually very common when the data are skewed. This is typically the case in our data (see the descriptive statistics in Appendix 5A). However, logging the data causes a number of problems. First, once logged the interaction terms $GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$ and $TCH_{t(j)} \times SKDIFF_{t(ij)}^{2}$ become collinear with other variables and must be dropped (Blonigen and Davies, 2004). In other words, logging the data changes the content of the model. The model then loses one of the key variables to capture that (vertical) FDI is high when the parent country is small and relatively skill abundant.

Second, the skill difference term $SKDIFF_{t(ij)}$ has both negative and positive values.[96] Logging the data means that negative values will be deleted from the sample. A possible solution is to multiply negative values of $SKDIFF_{t(ij)}$ by −1. However, multiplying negative values of $SKDIFF_{t(ij)}$ by −1 implies that one is imposing absolute skill differences and symmetry around zero.[97] Carr et al. (2003) object to taking absolute values. First, they argue that the knowledge-capital model does not predict symmetry around zero skill differences. Using simulation results they illustrate that, for values of skill differences between –0.30 and 0.30, the net volume of FDI increases as the parent becomes more skill abundant, both when the parent country *i* is relatively large and small. Second, if FDI from parent *i* to host *j* increases in absolute skill differences this means that FDI also increases when the host country becomes relatively more skill abundant. According to Carr et al. (2003) this is a result that is not consistent with the (factor-proportions) theory. According to Carr et al. by taking absolute values, one is no longer estimating the knowledge-capital model, but rather testing whether FDI generally increases with skill differences or skill similarities. In other words, this entails a test of whether FDI is best explained by the horizontal or the vertical model.

Hence, if we change the functional form, the empirical specification no longer represents the predictions of the knowledge-capital model. Nevertheless, Figure 5B.2 in Appendix 5B.2 indicates that changing the functional form goes a long way in solving the heteroskedasticity problem. The graphs show the residuals from estimating a log linear model for the OECD sample plotted against the fitted values. The graphs are far less pronounced than for the linear model. Hence, the graphs suggest that, from an econometric point of view, FDI of OECD countries is much better explained by a log linear model.

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[96] This is true also for the term $GDPDIFF_{t(ij)}$ but the latter would be omitted in a log linear model anyway because of multicollinearity.

[97] In this case we could have also used a dummy variable *skdifn* equal to 1 when $SKDIFF_{ij} < 0$ and 0 otherwise. The regression equation would then be as follows:

$$\ln FDI_{ij} = b_0 + b_1 \ln SUMGDP_{ij} + b_2 \ln(GDPDIFF_{ij})^2 + b_3 \ln SKDIFF_{ij} + b_4 \ln INVCH_j + b_5 \ln TCH_j$$

$$+b_6 \ln TCP_i + b_7 \ln DIST_{ij} + skdifn + b_8 skdifn * \ln SUMGDP_{ij} + b_9 skdifn * \ln(GDPDIFF_{ij})^2 + b_{10} skdifn *$$

$$\ln SKDIFF_{ij} + b_{11} skdifn * \ln INVCH_j + b_{12} skdifn * \ln TCH_j + b_{13} skdifn * \ln TCP_i + b_{14} skdifn * \ln DIST_{ij} + u_{ij}.$$

The first part of the regression equation would then give the estimated coefficients for the sample with positive skill differences. The second part (i.e. multiplied by *skdifn*) would give the difference between coefficients for the sample with positive and the sample with 'negative' skill differences.

5.2.3. Discussion

As discussed in Chapter 3, the empirical specification of the knowledge-capital model is rather complex compared to a more standard gravity equation so as to distinguish the different motivations of FDI. As it turns out the specification is not robust in the confrontation with data on bilateral FDI of the OECD. The subtractive linear restriction that parent and host-country skill abundances have equal but opposite effects on FDI, which serves to capture that differences in relative skill abundance give rise to vertical FDI, is rejected by the data. Also, a log linear specification is more appropriate. However, transforming the data alters the empirical specification, which subsequently no longer represents the predictions of the knowledge-capital model.

Besides, one may question the underlying assumptions regarding factor intensities that are used to distinguish vertical and horizontal FDI. As discussed in Chapter 3, evidence for American MNEs by Yeaple (2003) suggests that MNEs locate types of production abroad in a manner that exploits host countries' particular comparative advantage: in industries with high skilled-labour intensities, U.S. multinationals favour skilled-labour abundant countries over skilled-labour scarce countries, whereas in sectors with low skilled-labour intensities U.S. multinationals favour skill-scarce countries over skilled-labour abundant countries. Yeaple's results imply that vertical FDI may very well be driven by skill similarities too, depending on the industry.[98] Thus, the distinction between horizontal and vertical FDI on the basis of skill differences/similarities may not be so sharp in practice.

Given the evidence in this section, we reject the knowledge-capital model as a model to explain bilateral FDI of OECD countries. In the next section we estimate a gravity model for bilateral FDI of the OECD.

5.3. A gravity model of bilateral FDI

In this section we use a gravity equation to investigate the determinants of bilateral FDI. This entails that we no longer distinguish between horizontal and vertical FDI, but rather seek to explain the overall pattern of bilateral FDI of the OECD. We start off with a basic gravity specification in which market size and skilled labour are the main explanatory variables (cf. the knowledge-capital model). Next, we extend the specification with additional variables.

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[98] To the extent that vertical FDI occurs in skill-intensive sectors, FDI between countries that are similar in skill endowments may be wrongly taken as horizontal. This may – in part – explain why Markusen and Maskus (2002) find that a horizontal model FDI finds most confirmation in the data (see Section 3.3).

5.3.1. Basic model and data

Our basic regression equation looks as follows:

$$\ln(FDI_{t(ij)}) = \beta_0 + \beta_1 \ln(GDP_{t(i)}) + \beta_2 \ln(GDP_{t(j)}) + \beta_3 \ln(SKILL_{t(i)}) + \beta_4 \ln(SKILL_{t(j)}) + \beta_5 \ln(Dist_{t(ij)}) + \varepsilon_{t(ij)}. \tag{5.2}$$

The equation takes on market size and skilled labour endowments as important determinants of FDI (cf. the knowledge-capital model). We truncate negative values of FDI to 0.1 before taking logs (cf. Blonigen and Davies, 2004).

With respect to skilled-labour endowments we distinguish measures of human capital and skilled-labour abundance. We use the indicator of labour-force quality *QL* constructed by Hanushek and Kim (1995) and the share of skilled labour (the sum of ISCO-68 categories 0/1 (professional, technical and kindred workers) and 2 (administrative workers)) in total employment used by CMM as proxies for skilled labour.[99] Both indicators measure a different dimension of skilled labour. *QL* is a proxy for the quality of human capital (*qualitative*); the indicator used in CMM is a (*quantitative*) measure of skilled-labour abundance.

The specifications also control for a shared cultural background by way of a dummy variable indicating whether countries share a common language and a dummy variable indicating whether countries share a colonial past.[100] Together with geographical distance, these dummy variables capture (distance-related) trade and investment costs. Chapter 6 extends this analysis and empirically examines the effect of multiple dimensions of distance.

We also include year dummies to control for global trends. Most year dummies are statistically insignificant and we do not report them. Descriptive statistics are presented in Appendix 5A.

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[99] As argued in Chapter 2, the Barro and Lee indicators of educational attainment used in BDH merely measure the quantity (years) of schooling. They do not adjust for quality differences across countries. Appendix 5C presents results of estimating the knowledge-capital model using the *QL*.

[100] Dummy variables indicating whether countries share a common language, common religion and common colonial history have proven to be effective controls for shared cultural background in the empirical trade literature (see, e.g., Frankel, 1997).

5.3.2. Basic results

The first two columns in Table 5.4 show the results for the basic specification of the gravity model including skilled labour. FDI increases with market size. That is, GDP has a positive and statistically significant effect on FDI. The literature often finds that international trade and FDI are more elastic with respect to the level of GDP in the origin country than GDP in the destination country. Our results confirm this pattern: the coefficients of GDP_i are larger than those of GDP_j. FDI is parent-income elastic: a one percent increase in parent-country GDP tends to raise FDI stocks on average by more than one per cent. The elasticity of FDI with respect to host-country GDP is below unity.

Column (1) indicates that skilled-labour abundance has a positive and statistically significant effect on bilateral FDI. FDI increases in both parent- and host-country skilled labour. This indicates that skilled-labour abundant countries undertake more outward FDI and also attract more (inward) FDI. Skilled-labour abundance of the parent-country has a particularly large effect on FDI in the basic specification: a one percentage point increase in the level of human capital raises FDI by 1.32 per cent. Human capital (the second column in Table 5.4) also has a positive and statistically significant effect on FDI. FDI is elastic with respect to human capital: a one percent increase in human capital of parent and host-country raises bilateral FDI on average by 1.86 and 1.45 per cent, respectively.

The results for the remaining variables in the basic specification are as expected. FDI decreases when physical distance increases. Sharing a common language and a colonial past has a positive effect on FDI. The semi-elasticities of 1.36 and 0.43 in the first column in Table 5.4 imply that bilateral FDI stocks between two countries that share a common language are almost four times the amount of bilateral FDI stocks between two countries whose languages differ, while FDI between two countries that share a colonial past is 53 per cent higher than two countries that do not, respectively.[101]

5.3.3. Adding GDP per capita

Our results in columns (1) and (2) of Table 5.4 indicate that skilled labour (both in terms of skilled-labour abundance and human capital) has a positive and statistically significant effect on FDI. Yet, to what extent does the positive and statistically significant effect of skilled-labour abundance and human capital truly reflect the effect of skilled labour on FDI? High-income, developed countries are generally also the ones with high levels of human capital and/or large endowments of skilled labour. Since we do not control for the

[101] The percentage impact of a dummy variable is calculated as $(e^{\beta_k}-1)*100\%$.

Table 5.4. Results gravity specifications of bilateral FDI, OLS

	Basic specification skills		GDP per capita	
Skill indicator:	Skill abundance	Human capital	Skill abundance	Human capital
	(1)	(2)	(3)	(4)
Log GDP parent	1.32***	1.25***	1.29***	1.20***
	(33.54)	(39.20)	(29.17)	(38.71)
Log GDP host	0.82***	0.76***	0.84***	0.73***
	(24.27)	(27.30)	(22.19)	(27.97)
Log Distance	–0.67***	–0.71***	–0.68***	–0.68***
	(18.48)	(24.38)	(18.63)	(24.91)
Language dummy	1.36***	1.38***	1.36***	1.06***
	(10.65)	(16.15)	(10.47)	(12.58)
Colonial dummy	0.43**	0.38***	0.49***	0.48***
	(2.51)	(2.99)	(2.81)	(4.13)
Log Skills parent	1.32***	1.86***	1.16***	2.97***
	(11.65)	(6.32)	(8.12)	(10.06)
Log Skills host	0.62***	1.45***	0.73***	–0.04
	(6.73)	(8.91)	(4.37)	(0.24)
Log GDP per capita parent			0.49	2.37***
			(1.54)	(11.74)
Log GDP per capita host			–0.16	0.76***
			(0.86)	(11.73)
Institutional quality parent				
Institutional quality host				
Constant	–12.71***	–27.36***	–15.65***	–54.09***
	(16.95)	(17.63)	(4.56)	(20.73)
Adjusted R^2	0.59	0.51	0.59	0.57
Observations	1423	2591	1423	2591
log likelihood	–2718	–5084	–2716	–4920

Absolute robust *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Year dummies included (not shown).

Table 5.4. Continued

	Institutions	
Skill indicator:	Skill abundance	Human capital
	(5)	(6)
Log GDP parent	1.41***	1.34***
	(30.28)	(39.01)
Log GDP host	1.05***	0.77***
	(22.97)	(27.38)
Log Distance	–0.65***	–0.61***
	(17.21)	(22.16)
Language dummy	1.35***	0.97***
	(10.52)	(11.64)
Colonial dummy	0.46***	0.35***
	(2.74)	(3.26)
Log Skills parent	–0.06	2.81***
	(0.26)	(9.46)
Log Skills host	0.36**	–0.04
	(2.00)	(0.23)
Log GDP per capita parent	0.04	0.68***
	(0.12)	(2.59)
Log GDP per capita host	–1.37***	0.50***
	(5.74)	(4.79)
Institutional quality parent	1.83***	1.45***
	(5.92)	(9.24)
Institutional quality host	1.30***	0.34***
	(7.59)	(3.98)
Constant	–11.82***	–40.86***
	(3.44)	(14.58)
Adjusted R^2	0.60	0.59
Observations	1423	2591
log likelihood	–2682	–4868

Absolute robust *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Year dummies included (not shown).

level of development, the results on skilled labour above may suffer from an omitted variable bias. To control for the level of development we include per capita GDP of the parent and the host country. Data on GDP per capita are from the Penn World Tables (Mark 5.6), in correspondence with our GDP data (see Chapter 3 and the Data Appendix in the back of this study). Columns (3) and (4) in Table 5.4 give the results.

The third column suggests that skilled-labour abundance is robust to the extension with per capita GDP. The coefficient on skilled-labour abundance of the parent is smaller, though, indicating that the estimate in column (1) is indeed somewhat biased.

GDP per capita of the parent is nearly statistically significant (10 per cent level). GDP per capita of the host has no statistically significant effect on FDI. These results could indicate that the structure of the labour force offers an explanation *why* more developed countries engage more in FDI: FDI is motivated by skilled-labour abundance, which is a characteristic of developed countries (cf. Chapter 2). However, the insignificance of GDP per capita of the host in specification (3) is more likely the result of multicollinearity. Correlation between host-country skilled labour and GDP per capita is high in the data.[102] In fact, we find the opposite results in the specification with human capital (column (4)): in this case, the effect on FDI of per capita GDP of the host is positive and statistically significant, whilst the effect of host-country human capital is statistically insignificant. These results typically indicate multicollinearity: due to the high correlation between host-country GDP per capita and skilled-labour abundance/human capital, it is difficult for the model to determine which variable is actually producing the effect on FDI. Coefficient estimates on these variables vary across the two samples. On the other hand, the effects on FDI of per capita GDP and human capital are both positive and statistically significant on the parent side. Thus, the quality of human capital and the level of development of the parent country contribute to FDI independently.

5.3.4. Adding institutions

Next, we include institutional quality. This is based on lessons from the empirical literature on international trade that omission of institutional quality in the gravity specification biases the estimates of GDP per capita (see, e.g., Anderson and Marcouiller, 2002, De Groot et al., 2004).[103] Is the effect of per capita GDP also biased in gravity models of FDI?

Kaufmann et al. (2005) have constructed six indicators of perceived institutional quality on the basis of principal components analysis. These indicators are: voice and accountability; political stability; government effectiveness; regulatory quality; rule of law; control of corruption. Institutional quality is calculated by taking the simple average of the scores across all six governance indicators. Descriptive statistics are given in Appendix 5A. The results are given in the last two columns of Table 5.4.

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[102] The correlation between host-country skilled-labour abundance and GDP per capita is 0.83; the correlation between host-country human capital and GDP per capita is 0.68. See the correlation matrix in Appendix 5A. We also estimated specifications with GDP per capita *excluding* skilled-labour abundance and human capital. We then find a positive and significant effect of GDP per capita on FDI for both the parent and the host-country side. See Table 5D.1 in Appendix 5D.

[103] GDP per capita proxies for omitted trade costs variables. Anderson and Marcouiller (2002) and De Groot et al. (2004) find a negative relationship between trade and income per capita in gravity specifications that include institutions. This may reflect that when countries become wealthier the share of total expenditure devoted to traded goods falls, because the structure of production and consumption shifts from commodities towards services. Not including institutional effectiveness can obscure this negative relationship, because of the high correlation between per capita income and the quality of governance.

Institutional quality has a positive and statistically significant effect for both the parent and the host-country side in specification (5). The coefficient on skilled-labour abundance of the host is smaller than in the previous two specifications (column (1) and (3)). The effect is statistically significant at the ten per-cent level. The effect of skilled-labour abundance of the parent, on the other hand, can no longer be identified independently. The same is true for the effect of per capita GDP of the parent.[104] These effects are the result, once again, of multicollinearity.[105]

Column (6) gives the results with human capital. Institutional quality once again has a positive and statistically significant effect on FDI. The effects of human capital and GDP per capita are largely robust to the extension with institutional quality, although the size of the parameter estimates on GDP per capita are much smaller compared to specification (4), indicating that the estimates in specification (4) capture (part of) the positive effect of institutions.

Discussion

The estimates on skilled labour, GDP per capita and institutional quality vary across different specifications. Adding or dropping variables produces shifts in parameters estimates and we even find sign changes. These results typically indicate multicollinearity. Multicollinearity is foremost a technical problem. It means that, due to the high correlation between variables, it is difficult for the model to identify the effects independently and determine which variable is actually producing the effect on FDI. As a result, the estimated effects vary across samples. Yet, estimates are still best linear unbiased (BLUE) and dropping variables to reduce the degree of multicollinearity would cause the estimators of the remaining variables to be inconsistent (omitted variables bias). The proper specification therefore includes all three variables, i.e., skilled labour, GDP per capita and institutional quality. Looking across the various specifications, we find positive effects on FDI from all three variables at one time or another. We conclude from this that skilled labour, the level of development and institutional quality are all likely determinants of FDI, but that their effects coincide.

[104] The coefficient on per capita GDP of the host becomes statistically significant in the specification with skilled-labour abundance. This is not the case in the regression with human capital. Table 5D.1 in Appendix 5D illustrates that the negative and statistically significant effect of GDP per capita of the host in the specification with skilled-labour abundance is probably a sample selection effect.

[105] Variance-inflation-factor (vif) values for institutional quality (parent and host), parent-country skilled-labour abundance and host-country per capita GDP are high (7.7 and beyond). Skilled-labour abundance, GDP per capita and institutional quality are highly correlated in the data (see the correlation matrix in Appendix 5A).

5.4. Additional robustness analysis – multilevel analysis

The results above are from a panel data set. The use of a panel data set will generally yield more efficient estimators than cross-sectional or time series data because data vary over two dimensions, countries and time (see, e.g., Verbeek, 2004). Nevertheless, the weaker the time-series variation in bilateral trade and FDI, the closer we are to merely running a series of cross-sections.[106] Significance levels (standard errors) of the regression coefficients may then be overstated (understated) due to dependence of observations. In this section, we therefore estimate results of a cross-classified multilevel version of the gravity model including skilled labour, GDP per capita and institutional quality.[107] As explained in Chapter 4, the general idea of the multilevel analysis in this study is first that higher-level (here, parent, host or parent-host-combination) heterogeneity has an impact on the dependent variable. Next, that because of these higher-level effects, 'years' (annual FDI values) for the same parent country i, host country j, or the same parent-host combination tend to be more alike. The multilevel model therefore accounts for the effects of parent, host or parent-host-combination heterogeneity on FDI and subsequently explains the variance between years for parent country i and host j. In this respect, the multilevel approach is equivalent to a procedure with parent, host and pair wise fixed effects. Yet, multilevel analysis has a number of advantages. First, in a cross-classified multilevel model, we can control for the effects of parent and host countries and parent-by-host interaction all at once without running into problems of multicollinearity. Second, and related to the previous, since a multilevel model estimates only the variances of country and interaction effects, we can still estimate the effects of the explanatory variables in a multilevel model. Third, a multilevel model is more parsimonious in terms of degrees of freedom than a specification with many dummy variables.

Table 5.5 presents the results. Cluster means are included (but not shown) to ensure unbiased coefficients on the explanatory variables.[108] Column (1) gives the results with skilled-labour abundance, column (2) with human capital.

We once again observe some effects from multicollinearity, in this case the negative coefficients of parent institutional quality in the specification with skilled-labour abundance and institutional quality of the host in the specification with human capital.[109]

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[106] See Appendix 5A for the calculation of the degree of clustering in the regression of the gravity model (N=2591).
[107] See Appendix 5D for the results of different specifications of the gravity model.
[108] We used the same procedure as in Chapter 4. That is, we first dropped cluster means that are highly correlated (> 0.9) with the explanatory variables. Next, we dropped cluster means that are highly (> 0.8) correlated with (an)other cluster mean(s). Which cluster means have been included is listed under Table 5.5.
[109] In Appendix 5D we show the effects from adding or dropping variables in (various specifications of) the gravity model.

Table 5.5. Results gravity specifications of bilateral FDI, multilevel model

Skill indicator:	Skill abundance	Human capital
	(1)	(2)
Log GDP parent	1.62***	1.41***
	(6.98)	(5.66)
Log GDP host	0.50**	0.38***
	(2.58)	(3.17)
Log Distance	–0.93***	–0.91***
	(7.63)	(10.36)
Language dummy	0.52	0.73***
	(1.52)	(2.85)
Colonial dummy	0.66	0.48
	(1.48)	(1.56)
Log Skills parent	3.52***	1.34
	(6.25)	(0.77)
Log Skills host	0.17	0.11
	(0.53)	(0.18)
Log GDP capita parent	2.13***	2.34***
	(4.06)	(6.27)
Log GDP capita host	0.54	1.28***
	(1.38)	(5.86)
Institutional quality parent	–0.52	2.32***
	(0.54)	(2.80)
Institutional quality host	0.24	–0.44
	(0.54)	(1.33)
Constant	103.54	2.78
	(1.26)	(0.05)
Observations	1423	2591
log likelihood	–1718	–3166

Absolute *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. The coefficients relate to within-country (pair) changes. Cluster means are included to ensure consistent estimators (not shown).

Means included in (1): GDP of parent by host country, GDP of host by parent country, GDP per capita and institutional quality of parent by host country, GDP per capita of host by parent country, and distance, language and colony by parent and host country.

Means included in (2): GDP of parent by host country, GDP of host by parent country, GDP per capita, institutional quality and human capital of parent by host country, GDP per capita of host by parent country, and distance, language and colony by parent and host country.

As for the other variables, they all have the expected sign in both specifications. In this sense, the sign patterns and coefficient sizes are qualitatively robust. Still, we do find that, when clustering of the data is taken into account, significance levels of the standard gravity variables GDP, distance, and the language and colonial dummy variables are lower. The effect of a common colonial past (and of a common language in the regression with skilled-labour abundance) is no longer statistically significant at the conventional significance levels. Hence, in this case, OLS leads to spuriously significant results.

As explained in Chapter 2 one can get a sense of the relative importance of explanatory variables by calculating standardised, or beta, coefficients. We calculated beta coefficients for specifications of the gravity model that include skilled labour, GDP per capita and institutional quality. This entails specifications (5) and (6) in Table 5.4 and the multilevel specifications in Table 5.5. The estimates give a range of minimum and maximum effect sizes. The beta coefficients based on this range are given in Table 5.6.

The beta coefficients indicate that an increase by one standard deviation in the skilled-labour abundance of the parent country can raise bilateral FDI by maximum 58 per cent of a standard deviation of bilateral FDI. A one standard deviation increase in the skilled-labour abundance of the host country can raise FDI by up to 7 per cent of a standard deviation of bilateral FDI. An increase of one standard deviation in human capital in the parent and the host can raise FDI by maximum 14 and 1 percent of a standard deviation of FDI, respectively. A one-standard-deviation-increase in institutional quality of a parent and a host country can increase FDI by maximum 30 and 32 percent of a standard deviation, respectively. A one standard deviation increase in the level of development of the parent country can increase FDI by up to 20 per cent of a standard deviation of FDI. For level of development of the host country, the corresponding increase is 32 per cent of a standard deviation of FDI.

Table 5.6. Beta coefficients of gravity specifications

Skill indicator:	Skill abundance		Human capital	
Log GDP parent	0.68	0.78	0.68	0.71
Log GDP host	0.25	0.53	0.20	0.41
Log Distance	–0.42	–0.30	–0.41	–0.28
Language dummy	0.07	0.19	0.11	0.14
Colonial dummy	0.04	0.06	0.04	0.05
Log Skills parent	–0.01	0.58	0.06	0.14
Log Skills host	0.03	0.07	0.00	0.01
Log GDP capita parent	0.00	0.18	0.06	0.20
Log GDP capita host	–0.25	0.10	0.15	0.37
Institutional quality parent	–0.07	0.25	0.19	0.30
Institutional quality host	0.06	0.32	–0.13	0.10

Beta coefficients based on specifications (5) and (6) of Table 5.4 and the multilevel estimates of Table 5.5. The table gives the relative importance based on the range of the estimates in Tables 5.4 and 5.5.

5.5. Conclusion

This chapter empirically examines the specification of the knowledge-capital model for FDI of the OECD. The distinctive feature of the knowledge-capital model is that, within aggregate FDI, it distinguishes between horizontal and vertical FDI. To capture the predictions of the vertical model, the empirical specification in CMM (i) imposes the subtractive linear constraint that the coefficients on parent and host country skilled-labour abundance are of equal size but opposite in sign; and (ii) includes the interaction between income differences and skill differences. To allow for such interaction terms, CMM do not log the data, but use a linear specification instead. The empirical specification of the knowledge-capital is derived from theory. We test the linear restrictions and the functional form of the knowledge-capital model. This chapter finds that the subtractive linear restriction that parent and host-country skill abundances have equal but opposite effects on FDI, which serves to capture that differences in relative skill abundance give rise to vertical FDI, is rejected by the data. A specification in which parent and host-country skilled labour are estimated separately thus seems more appropriate. Also, a log linear model is more appropriate. However, transforming the data alters the empirical specification, which subsequently no longer represents the predictions of the knowledge-capital model. Given the empirical evidence in this chapter, we reject the knowledge-capital model as a model to explain bilateral FDI stocks of OECD countries on statistical grounds.

We subsequently estimate a gravity model of bilateral FDI. This entails that we no longer distinguish between horizontal and vertical FDI, but rather seek to explain the overall pattern of bilateral FDI of the OECD. With regard to skilled labour, we look at skilled-labour abundance as well as human capital. Next, we extend the gravity specification with GDP per capita (a proxy for the level of development) and institutional quality. Despite econometric difficulties to identify the effects of each variable independently, we find positive effects on FDI from all three variables at one time or another. We conclude that skilled labour, the level of development and institutional quality are all likely determinants of FDI.

How can we interpret the results concerning skilled labour, institutions and level of development from the gravity specifications? We find that both parent- and host-country skilled labour, institutions and level of development affect FDI positively. First, concerning skilled labour this suggest that MNEs arise in countries that are skilled-labour abundant and/or have high levels of human capital (high-quality schooling) and that this is also what makes them choose one location to host their foreign activities over another. Firms' choice of a suitable location is also affected by costs. The costs – adjustment costs and additional lack of trust and confidence in security of transactions – will be lower when differences in the institutional environment between the parent and the host country are small (Linders, 2006). These results suggest that 'proximity' between parent and host countries is the key in explaining bilateral FDI: MNEs choose locations that are ‘close’ to the parent country in terms of skilled labour endowments and/or quality and in terms of institutional quality. The importance of the level of development for FDI may be explained by the importance of skilled labour and institutional quality. High-income, developed countries are generally also the ones with high levels of human capital and/or large endowments of skilled labour, as well as high-quality institutions. With reference to the empirical literature on economic growth and development (cf. Chapter 2), we assume that the causality runs from skilled labour and institutions to the level of development rather than the other way around. On the other hand, the level of development can also reflect the ‘quality’ of demand (income-related pattern of demand). In this case, the level of development has its own impact on FDI. In this case, proximity again matters, this time in terms of proximity of production and demand patterns.

Appendix 5A. Data

Table 5A.1 gives the descriptive statistics for regressions of the gravity model with human capital (*QL* indicator).

Table 5A.1 – Summary statistics gravity model sample (*N*=2591)

Variable	Mean	Standard deviation	Minimum	Maximum
Log FDI_{ij}	6.27	2.48	–2.30	12.1
Log GDP parent	13.4	1.25	8.10	15.3
Log GDP host	12.2	1.33	7.91	15.3
Log Distance	8.33	1.13	5.16	9.88
Language dummy	0.16	0.37	0	1
Colonial dummy	0.07	0.25	0	1
Log skills parent (*QL*)	4.01	0.12	3.85	4.18
Log skills host (*QL*)	3.92	0.26	3.03	4.28
Log GDP cap parent	9.51	0.21	8.53	9.80
Log GDP cap host	8.99	0.72	6.84	9.80
Institutional quality parent	1.50	0.32	0.59	1.90
Institutional quality host	1.13	0.74	–0.46	1.93

Table 5A.2 gives the descriptive statistics for regressions of the gravity model with relative skill endowments.

Table 5A.2 – Summary statistics gravity model (*N*=1423)

Variable	Mean	Standard deviation	Minimum	Maximum
Log FDI_{ij}	6.54	2.55	–2.30	12.08
Log GDP parent	13.2	1.23	11.0	15.3
Log GDP host	12.25	1.29	9.99	15.3
Log Distance	8.19	1.16	5.16	9.84
Language dummy	0.16	0.36	0	1
Colonial dummy	0.06	0.23	0	1
Log Skill abundance parent	–1.54	0.42	–2.53	–1.08
Log Skill abundance host	–1.73	0.51	–3.00	–1.08
Log GDP cap parent	9.52	0.22	8.53	9.80
Log GDP cap host	9.24	0.47	7.83	9.80
Institutional quality parent	1.51	0.35	0.59	1.90
Institutional quality host	1.33	0.62	–0.17	1.93

Tables 5A.3 – 5A.5 present correlation matrices.

Table 5A.3 – Correlation matrix sample (*N*=2591)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1. Log FDI stock	1											
2. Log GDP parent	0.44	1										
3. Log GDP host	0.30	–0.13	1									
4. Log Distance	–0.15	0.31	0.03	1								
5. Language dummy	0.23	0.06	–0.07	0.00	1							
6. Colony	0.18	0.06	0.09	0.07	0.38	1						
7. Log Skills parent (*QL*)	–0.14	–0.37	0.06	0.01	–0.09	0.05	1					
8. Log Skills host (*QL*)	0.13	–0.09	–0.12	–0.21	0.07	0.06	–0.02	1				
9. Log GDP cap parent	0.32	0.31	0.05	0.11	0.18	0.04	–0.33	0.04	1			
10. Log GDP cap host	0.24	–0.21	0.03	–0.31	0.10	0.04	0.02	0.68	0.05	1		
11. Inst. quality parent	0.18	–0.14	–0.05	–0.14	0.17	0.06	–0.11	0.05	0.60	0.08	1	
12. Inst. quality host	0.17	–0.17	–0.16	–0.30	0.17	0.06	0.02	0.63	0.03	0.86	0.07	1

Table 5A.4 – Correlation matrix sample (*N*=1423)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1. Log FDI stock	1											
2. Log GDP parent	0.47	1										
3. Log GDP host	0.29	–0.10	1									
4. Log Distance	–0.09	0.32	0.13	1								
5. Language dummy	0.27	0.04	–0.09	–0.01	1							
6. Colony	0.21	0.09	0.06	0.08	0.38	1						
7. Log Skill abun'ce parent (ILO)	0.22	–0.09	–0.04	–0.07	0.20	0.14	1					
8. Log Skill abun'ce host (ILO)	0.17	–0.12	–0.02	–0.22	0.22	0.08	0.04	1				
9. Log GDP cap parent	0.34	0.33	–0.09	0.12	0.17	–0.02	0.64	0.04	1			
10. Log GDP cap host	0.20	–0.15	0.20	–0.20	0.21	0.03	0.06	0.83	0.03	1		
11. Inst. quality parent	0.16	–0.24	–0.03	–0.18	0.15	0.05	0.91	0.04	0.58	0.07	1	
12. Inst. quality host	0.11	–0.11	–0.21	–0.23	0.26	0.06	0.04	0.84	0.04	0.85	0.06	1

Table 5A.5 – Correlation matrix different indicators skilled labour

	Log Skills parent (B&L)	Log Skills host (B&L)	Log Skills parent (*QL*)	Log Skills host (*QL*)
1. Log Skills parent (*QL*)	0.25			
2. Log Skills host (*QL*)		0.57		
3. Log Skill abundance parent (ILO)	0.58		0.28	
4. Log Skill abundance host (ILO)		0.75		0.56

Observations on FDI are clustered within parent and host countries and within parent and host combinations. Table 5A.6 gives the estimates of the within-variance σ_e^2 as well as the between-variances for parent and host countries and parent-host combinations, for two different baseline models, one including and the other excluding the combination effect c_{0ij}. Note that the model including c_{0ij} has a much better fit in terms of the log likelihood $-2LL$. All three variances are statistically significant. To test the significance of the variances we compare the $-2LL$ of the model including all three effects with the corresponding $-2LL$ value of the model without p_{0i}, h_{0j} and c_{0ij}, respectively (see Snijders and Bosker, 1999). An effect is significant if its inclusion decreases the $-2LL$. The difference in $-2LL$ is Chi-squared distributed with 1 degree of freedom. (In general, the number of degrees of freedom equals the number of parameters in an unrestricted model, including random effects, that have to be set to zero to obtain the restricted model.) In the case at hand, not including p_{0i}, h_{0j} or c_{0ij} causes the value of $-2LL$ to increase by 230, 130 and 2063, respectively. These increases are highly significant. Based on the estimates of this model, the correlation of two FDI values drawn from the same parent country or host country is 0.49 and 0.21, respectively. The correlation of two FDI values drawn from the same parent-host combination is 0.92. We conclude that intra-class correlation needs to be taken into account in order to make correct inferences.

Table 5A.6 – Estimates of covariance parameters and intra-class correlations

	Estimates of model $FDI_{t(ij)} = b_{00} + p_{0i} + h_{0j} + e_{t(ij)}$	Estimates of model $FDI_{t(ij)} = b_{00} + p_{0i} + h_{0j} + c_{0ij}$
Level 1		
Individual variance, σ_e^2	1.98	0.66
Level 2		
Parent country variance, σ_{0p}^2	4.65	4.30
Host country variance, σ_{0h}^2	2.43	1.88
Parent-host combination variance, σ_{0ph}^2	-	1.86
Intra-class correlation		
Same parent country		0.49
Same host country		0.21
Same parent / host combination		0.92
$-2LL$	9937	7875

Dependent variable: log $FDI_{t(ij)}$.

Appendix 5B.1 – Testing multiplicative heteroskedasticity

If we do not wish to specify the type of heteroskedasticity we can simply use heteroskedasticity-consistent (White) standard errors. This procedure uses an alternative formula for computing the OLS covariance matrix (Verbeek, 2004).[110] If, on the other hand, we are willing to make assumptions about the form of heteroskedasticity, we can use the more efficient generalised least squares (GLS) estimator. In the main text we have assumed multiplicative heteroskedasticity of the form $\sigma_i^2 = \sigma^2 \exp\{z_i'\alpha\}$. In this appendix we test the assumption of multiplicative heteroskedasticity and investigate what form is most appropriate. We consider two specifications for $\{z_i'\alpha\}$: a specification where z_i is the full set of explanatory variables in the knowledge-capital model ($z = X$), and, in order to check whether the former specification for the form of heteroskedasticity is not too restrictive, a specification where the squared terms are also included.

A test of the assumption of multiplicative heteroskedasticity is based on the F-value of the auxiliary regression of log e_i^2 on z_i and a constant. The results where $z = X$ are given in Table 5B.1. The F-value of the auxiliary regressions is 129.7 and 50.6, respectively. Hence, the null hypothesis that all coefficients except the intercept are equal to zero, i.e. the assumption of homoskedasticity, is decidedly rejected for both indicator sets.

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[110] Under Gauss-Markov conditions the variance of the OLS estimator b is routinely calculated as $\sigma^2(X'X)^{-1}$. When the condition of homoskedasticity no longer applies the covariance matrix of b becomes $(X'X)^{-1}X'Diag\{\sigma_i^2\}X(X'X)^{-1}$. Heteroskedasticity-consistent (White) standard errors use a consistent estimator $\frac{1}{N}\sum_{i=1}^{N} e_i^2 x_i x_i'$ for $\Sigma = \frac{1}{N} X'Diag\{\sigma_i^2\}X$.

Table 5B.1 – Auxiliary regressions multiplicative heteroskedasticity, $z = X$

	BDH indicators	CMM indicators
$SUMGDP_{t(ij)}$	0.0012^{***}	0.001^{***}
	(14.03)	(12.74)
$(GDPDIFF_{t(ij)})^2$	2.43e-08	$-7.73\text{e-}08^{***}$
	(1.12)	(3.38)
$SKDIFF_{t(ij)}$	-0.05^{*}	0.80
	(1.86)	(1.41)
$GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$	-0.0002^{***}	-0.004^{***}
	(9.85)	(11.09)
$INVC_{t(j)}$	-0.03^{***}	-0.02^{**}
	(6.27)	(2.49)
$TCH_{t(j)}$	0.002^{**}	0.001
	(2.28)	(0.13)
$TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2$	0.00019^{***}	0.09
	(2.88)	(1.02)
$TCP_{t(i)}$	0.003	0.02^{***}
	(1.04)	(3.35)
$DIST_{ij}$	0.00005^{***}	0.00003^{**}
	(4.69)	(2.11)
Constant	14.76^{***}	14.67^{***}
	(67.88)	(50.25)
Adjusted R^2	0.32	0.23
F-value	129.7	50.6
Observations	2460	1474

Dependent variable log e_i^2, where the e_i are the residuals from estimating the knowledge-capital model given in (5.1).

Table 5B.2 presents the results of the auxiliary regressions where z_i is the full set of explanatory variables and the squared terms. F-values, 71.5 and 28.0, respectively, indicate that the assumption of homoskedasticity is also rejected for this specification of $\{z_i'\alpha\}$.

Which specification for the form of $\{z_i'\alpha\}$ is most appropriate? We perform an F-test on the nine restrictions implied by the specification $z = X$ in Table 5B.1. This produces an F-statistic of 9.36 and 4.40, so the null hypothesis is rejected for both indicator sets. In other words, the specification that also includes the squared terms performs significantly better than the specification that only includes the knowledge-capital variables.

Table 5B.2 – Auxiliary regressions multiplicative heteroskedasticity, $z = X + X^2$

	BDH indicators	CMM indicators
$SUMGDP_{t(ij)}$	0.002***	0.0006***
	(8.31)	(3.38)
$(GDPDIFF_{t(ij)})^2$	–1.32e-08	–1.99e-08
	(0.19)	(0.21)
$SKDIFF_{t(ij)}$	–0.06**	1.10*
	(2.19)	(1.88)
$GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$	–0.0002***	–0.01***
	(7.46)	(7.97)
$INVC_{t(j)}$	–0.0007	0.07*
	(0.03)	(1.74)
$TCH_{t(j)}$	0.003*	0.04*
	(1.74)	(1.84)
$TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2$	–0.00002	0.14
	(0.20)	(0.30)
$TCP_{t(i)}$	–0.01	0.04
	(1.07)	(1.03)
$DIST_{ij}$	–0.00008**	–0.00002
	(2.33)	(0.60)
$\{SUMGDP_{t(ij)}\}^2$	–6.41e-08**	9.35e-08***
	(2.39)	(3.00)
$\{(GDPDIFF_{t(ij)})^2\}^2$	3.29e-15	–3.61e-15
	(1.18)	(0.89)
$\{SKDIFF_{t(ij)}\}^2$	0.01	–5.81
	(1.61)	(0.44)
$\{GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}\}^2$	1.17e-09	1.27e-06
	(1.24)	(1.45)
$\{INVC_{t(j)}\}^2$	–0.0004	–0.001**
	(1.23)	(2.12)
$\{TCH_{t(j)}\}^2$	–9.41e-06	–0.0007**
	(1.13)	(2.28)
$\{TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2\}^2$	7.93e-08***	0.04
	(4.41)	(0.58)
$\{TCP_{t(i)}\}^2$	0.0001	–0.0002
	(1.35)	(0.50)
$\{DIST_{ij}\}^2$	8.03e-09***	4.13e-09*
	(4.14)	(1.77)
Constant	14.43***	12.43***
	(27.19)	(13.94)
Adjusted R^2	0.34	0.25
F-value	71.5	28.0

Dependent variable log e_i^2, where the e_i are the residuals from estimating the knowledge-capital model given in (5.1).

Testing the linear restrictions

The main text gives the results of testing the linear restrictions in the knowledge-capital model for the WLS regression assuming that the error variance depends on the knowledge-capital variables only ($z = X$). In Tables 5B.3 and 5B.4 we present the results for the assumption that the error variance depends on the knowledge-capital variables and their square values, $z = X + X^2$. The restriction on the skill variables is once again rejected.

Table 5B.3 – Testing restrictions BDH indicators. $z = X + X^2$

H_0	Keeping the other linear restriction (on GDP or skills)		Unrestricted model	
	F-statistic	5%	*F*-statistic	5%
1. $\beta_1 = \beta_2$	$F(1, 2449) = 4.50$	Rejected	$F(1, 2448) = 8.11$	Rejected
2. $\beta_4 = -\beta_5$	$F(1, 2449) = 4.78$	Rejected	$F(1, 2448) = 12.2$	Rejected
Signs skill variables	$\beta_4>0$ $\beta_5<0$			
3. $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$			$F(2, 2448) = 10.2$	Rejected

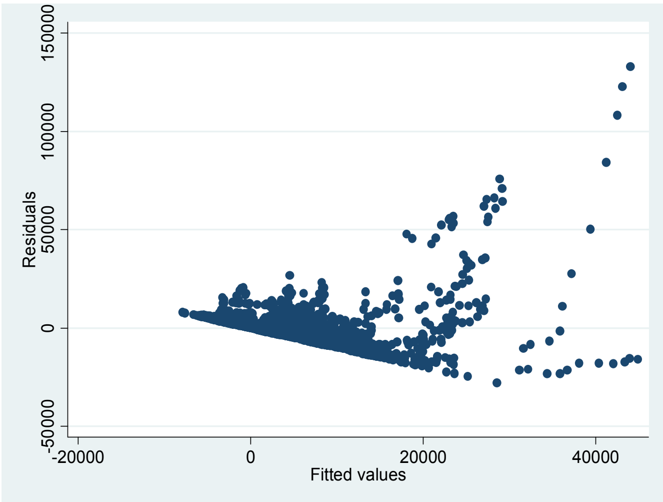
Table 5B.4 – Testing restrictions CMM indicators. $z = X + X^2$

H_0	Keeping the other linear restriction (on GDP or skills)		Specification without linear restrictions	
	F-statistic	5%	*F*-statistic	5%
1. $\beta_1 = \beta_2$	$F(1, 1463) = 8.93$	Rejected	$F(1, 1462) = 3.08$	Not rejected
2. $\beta_4 = -\beta_5$	$F(1, 1369) = 69.4$	Rejected	$F(1, 1462) = 41.4$	Rejected
Signs skill variables	$\beta_4>0$ $\beta_5>0$			
3. $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$			$F(2, 1462) = 24.6$	Rejected

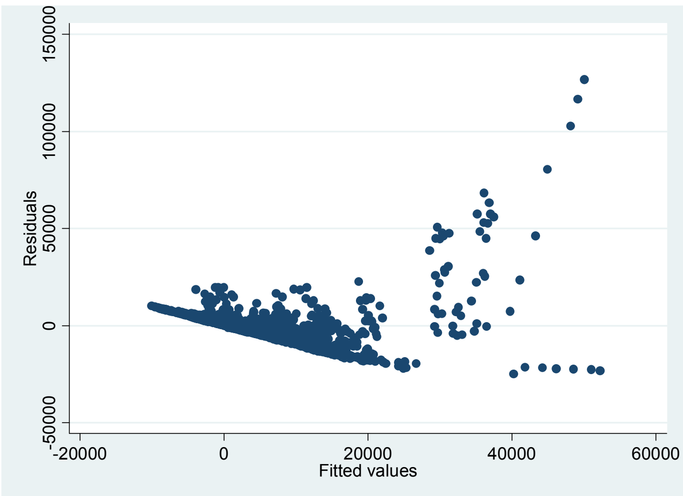
Appendix 5B.2 – Heteroskedasticity and functional form

Figure 5B.1 shows the residuals from estimating the knowledge-capital model for bilateral FDI of the OECD plotted against the fitted values (using the BDH indicators and the CMM indicators of skilled labour and trade and investment costs, respectively). The figures indicate the clear presence of heteroskedasticity.

Figure 5B.1 – Residuals versus fitted values, the knowledge-capital model



BDH indicators

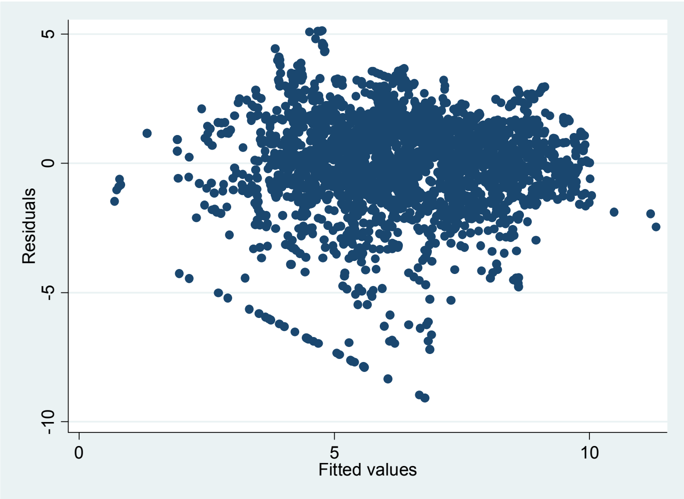


CMM indicators of skilled labour and trade and investment costs

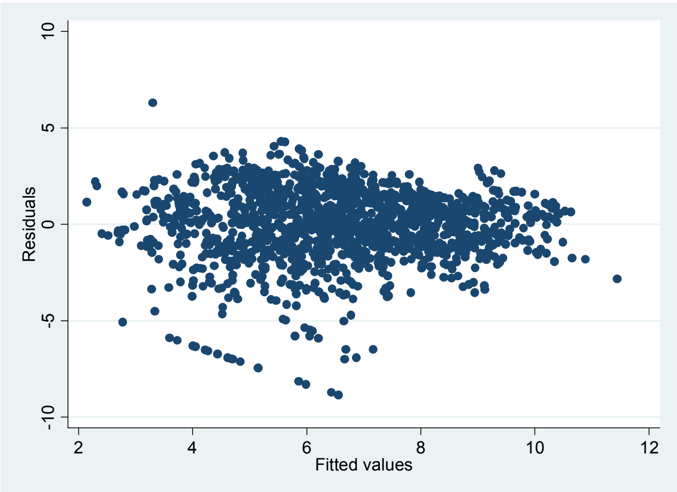
Changing the functional form

Figure 5B.2 shows the residuals from estimating a log linear model for FDI of the OECD plotted against the fitted values. The figure indicates that changing the functional form goes a long way in solving the heteroskedasticity problem. The graphs are far less pronounced than for the linear model. Hence, the graphs suggest that a log linear model is a more appropriate specification given the data.

Figure 5B.2 – Residuals versus fitted values log linear model



BDH indicators



CMM indicators of skilled labour and trade and investment costs

Appendix 5C. Linear restrictions in the knowledge-capital model using *QL*

This appendix presents the results from testing the linear restrictions of the knowledge-capital model using the *QL* indicator of skilled labour.

Like before, we use weighted least squares (WLS) estimators. We assume multiplicative heteroskedasticity of the form $\sigma_i^2 = \sigma^2 \exp\{z_i'\alpha\}$ (see below for tests of this assumption).

Tables 5C.1 and 5C.2 give the results of testing the linear restrictions in the knowledge-capital model for the WLS regression assuming that the error variance depends on the knowledge-capital variables only ($z = X$). Once again, the subtractive linear constraint that coefficients on parent and host country skilled-labour abundance are equal, but opposite in sign, is rejected for the *QL* indicator.

Table 5C.1 – Linear restrictions using *QL*, BDH indicators trade & investment costs. $z = X$

H_0	Keeping the other linear restriction (on GDP or skills)		Specification without linear restrictions	
	F-statistic	5%	*F*-statistic	5%
1. $\beta_1 = \beta_2$	$F(1, 2439) = 2.65$	Not rejected	$F(1, 2438) = 3.67$	Not rejected
2. $\beta_4 = -\beta_5$	$F(1, 2439) = 5.86$	Rejected	$F(1, 2438) = 6.21$	Rejected
Signs skill variables	$\beta_4>0$ $\beta_5<0$			
3. $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$			$F(2, 2438) = 4.27$	Rejected
Signs skill variables			$\beta_4>0$ $\beta_5<0$	

Table 5C.2 – Linear restrictions using *QL*, CMM indicators trade & investment costs. $z = X$

H_0	Keeping the other linear restriction (on GDP or skills)		Specification without linear restrictions	
	F-statistic	5%	*F*-statistic	5%
1. $\beta_1 = \beta_2$	$F(1, 1776) = 0.03$	Not rejected	$F(1, 1775) = 0.01$	Not rejected
2. $\beta_4 = -\beta_5$	$F(1, 1776) = 32.7$	Rejected	$F(1, 1775) = 33.7$	Rejected
Signs skill variables	$\beta_4>0$ $\beta_5<0$			
3. $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$			$F(2, 1775) = 16.95$	Rejected
Signs skill variables			$\beta_4>0$ $\beta_5<0$	

Tables 5C.3 and 5C.4 present the results for the assumption that the error variance depends on the knowledge-capital variables and their squares. The subtractive linear constraint that coefficients on parent and host country skilled-labour abundance are equal, but opposite in sign, is rejected in the specification with CMM indicators of trade and investment costs, but not in the specification with the BDH indicators.

Table 5C.3 – Linear restrictions using *QL*, BDH indicators trade & investment costs. $z = X + X^2$

H_0	Keeping the other linear restriction (on GDP or skills)		Specification without linear restrictions	
	F-statistic	5%	*F*-statistic	5%
1. $\beta_1 = \beta_2$	$F(1, 2439) = 5.96$	Rejected	$F(1, 2438) = 1.98$	Not rejected
2. $\beta_4 = -\beta_5$	$F(1, 2439) = 3.82$	Not rejected	$F(1, 2438) = 1.91$	Not rejected
Signs skill variables	$\beta_4>0$ $\beta_5<0$			
3. $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$			$F(2, 2438) = 2.24$	Not rejected
Signs skill variables			$\beta_4>0$ $\beta_5<0$	

Table 5C.4 – Linear restrictions using *QL*, CMM indicators trade & investment costs. $z = X + X^2$

H_0	Keeping the other linear restriction (on GDP or skills)		Specification without linear restrictions	
	F-statistic	5%	*F*-statistic	5%
1. $\beta_1 = \beta_2$	$F(1, 1776) = 0.15$	Not rejected	$F(1, 1775) = 0.12$	Not rejected
2. $\beta_4 = -\beta_5$	$F(1, 1776) = 25.6$	Rejected	$F(1, 1775) = 24.5$	Rejected
Signs skill variables	$\beta_4>0$ $\beta_5<0$			
3. $\beta_1 = \beta_2$ and $\beta_4 = -\beta_5$			$F(2, 1775) = 12.7$	Rejected
Signs skill variables			$\beta_4>0$ $\beta_5<0$	

Testing the assumption of multiplicative heteroskedasticity

Table 5C.5 gives the results of the auxiliary regression of log e_i^2 on z_i and a constant, where $z = X$. The *F*-value of the auxiliary regressions is 126.5 and 57.7, respectively. Hence, the null hypothesis that all coefficients except the intercept are equal to zero, i.e. the assumption of homoskedasticity, is decidedly rejected for both specifications. Coefficients are often statistically significant as well.

Table 5C.5 – Auxiliary regressions multiplicative heteroskedasticity, $z = X$

	QL & BDH indicators trade and investment costs	*QL* & CMM indicators trade and investment costs
$SUMGDP_{t(ij)}$	0.0011^{***}	0.0011^{***}
	(13.75)	(12.65)
$(GDPDIFF_{t(ij)})^2$	$-1.05e\text{-}07^{***}$	$-1.80e\text{-}07^{***}$
	(5.70)	(7.77)
$SKDIFF_{t(ij)}$	0.02^{***}	0.03^{***}
	(3.93)	(4.47)
$GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$	-0.00002^{***}	-0.00002^{***}
	(6.51)	(7.20)
$INVC_{t(j)}$	-0.06^{***}	-0.05^{***}
	(12.76)	(6.80)
$TCH_{t(j)}$	-0.001	-0.02^{**}
	(0.69)	(2.47)
$TCH_{t(j)} \times SKDIFF_{t(ij)}{}^2$	$6.34e\text{-}06^{**}$	$-5.88e\text{-}06$
	(2.41)	(1.26)
$TCP_{t(i)}$	-0.01^{***}	0.01^{**}
	(3.46)	(2.51)
$DIST_{ij}$	0.00008^{***}	$8.50e\text{-}06$
	(7.90)	(0.76)
Constant	16.34^{***}	16.61^{***}
	(78.66)	(50.88)
Adjusted R^2	0.32	0.22
F-value	126.5	57.7
Observations	2450	1787

Dependent variable log e_i^2, where the e_i are the residuals from estimating the knowledge-capital model given in (5.1).

Table 5C.6 presents the results of the auxiliary regressions where z_i is the full set of explanatory variables and the squared terms. F-values, 73.2 and 32.0, respectively, indicate that the assumption of homoskedasticity is also rejected for this specification of $\{z_i'\alpha\}$.

Which specification for the form of $\{z_i'\alpha\}$ is most appropriate? We perform an F-test on the nine restrictions implied by the specification $z = X$ in Table 5C.5. This produces an f-statistic of 13.9 and 5.23, respectively, so the null hypothesis is rejected in both cases. In other words, the specification that also includes the squared terms performs significantly better than the specification that only includes the knowledge-capital variables.

Table 5C.6 – Auxiliary regressions multiplicative heteroskedasticity, $z = X + X^2$

	QL & BDH indicators trade and investment costs	*QL* & CMM indicators trade and investment costs
$SUMGDP_{t(ij)}$	0.0015***	0.0012***
	(8.10)	(6.91)
$(GDPDIFF_{t(ij)})^2$	–2.47e-07 ***	–2.55e-07***
	(4.04)	(2.81)
$SKDIFF_{t(ij)}$	0.03***	0.03***
	(4.44)	(4.01)
$GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}$	–0.00001***	–0.00002***
	(5.45)	(5.29)
$INVC_{t(j)}$	0.02	–0.12***
	(0.94)	(3.01)
$TCH_{t(j)}$	0.001	0.02
	(0.30)	(0.83)
$TCH_{t(j)} \times SKDIFF_{t(ij)}^2$	0.00001***	0.00004*
	(3.27)	(1.68)
$TCP_{t(i)}$	–0.01	–0.02
	(1.26)	(0.47)
$DIST_{ij}$	–0.00015***	–0.0001***
	(4.60)	(2.66)
$\{SUMGDP_{t(ij)}\}^2$	–4.89e-08*	–7.25e-09
	(1.83)	(0.24)
$\{(GDPDIFF_{t(ij)})^2\}^2$	6.12e-15**	2.25e-15
	(2.30)	(0.56)
$\{SKDIFF_{t(ij)}\}^2$	–0.0007**	–0.0015
	(1.99)	(1.46)
$\{GDPDIFF_{t(ij)} \times SKDIFF_{t(ij)}\}^2$	1.78e-10***	2.61e-10***
	(3.77)	(4.22)
$\{INVC_{t(j)}\}^2$	–0.001***	0.001*
	(3.20)	(1.86)
$\{TCH_{t(j)}\}^2$	0.00001	–0.0005*
	(1.45)	(1.65)
$\{TCH_{t(j)} \times SKDIFF_{t(ij)}^2\}^2$	6.15e-11***	–2.76e-10***
	(2.82)	(2.63)
$\{TCP_{t(i)}\}^2$	–2.73e-06	0.0005
	(0.04)	(1.01)
$\{DIST_{ij}\}^2$	1.41e-08***	6.16e-09***
	(7.46)	(2.83)
Adjusted R^2	0.35	0.24
F-value	73.2	32.0

Dependent variable log e_i^2, where the e_i are the residuals from estimating the knowledge-capital model given in (5.1). Intercept was estimated but not shown.

Appendix 5D. Background gravity specifications

In this Appendix we present results of various specifications of the gravity model. We use different estimation samples. These specifications provide the background for references to sample selection effects and the effects from adding/dropping variables made in Sections 5.3 and 5.4 in the main text.

OLS

Table 5D.1 below presents OLS estimations of gravity specifications *excluding* skilled labour. We use different estimation samples: N=2629 (the set of maximum observations in the data); N=2591 (the number of observations in the regressions with human capital); and N=1423 (the number of observations in the regressions with skilled-labour abundance). In column (6) we find that, when institutional quality is included, the coefficient on per capita GDP of the host becomes negative and statistically significant with N=1423. We do not find this result for the larger samples. These results suggest that the negative and statistically significant effect of GDP per capita of the host column (5) in Table 5.4 is due to a sample selection effect.

Multilevel estimation

Tables 5D.2 and 5D.3 give the results for different specifications of the gravity model with multilevel estimation. The tables give results for N=1423 observations (the sample with skilled-labour abundance) and N=2591 (the sample with human capital). Table 5D.2 gives the results of the basic gravity equation (specifications (1) and (3)) and specifications including GDP per capita. Table 5D.3 illustrates the effect on FDI of institutional quality from including GDP per capita and skilled labour.

Table 5D.1 – Results standard gravity equations for different sample sizes, OLS

	GDP per capita			Adding institutional quality		
	Full sample	Sample human cap	Sample skill abun'ce	Full sample	Sample human cap	Sample skill abun'ce
	(1)	(2)	(3)	(4)	(5)	(6)
Log GDP parent	1.11***	1.11***	1.15***	1.26***	1.27***	1.40***
	(37.12)	(36.88)	(26.54)	(40.09)	(40.13)	(30.37)
Log GDP host	0.72***	0.72***	0.79***	0.75***	0.77***	1.05***
	(27.67)	(27.36)	(21.09)	(27.94)	(26.97)	(22.98)
Log Distance	–0.63***	–0.63***	–0.72***	–0.56***	–0.56***	–0.66***
	(23.28)	(23.32)	(19.33)	(20.53)	(20.63)	(17.62)
Language dummy	1.01***	1.01***	1.40***	0.92***	0.92***	1.35***
	(11.68)	(11.65)	(10.65)	(10.77)	(10.72)	(10.57)
Colonial dummy	0.59***	0.60***	0.96***	0.46***	0.46***	0.49***
	(4.83)	(4.84)	(5.11)	(4.10)	(4.07)	(2.86)
Log GDP/cap parent	1.94***	1.95***	2.22***	0.26	0.22	0.07
	(9.88)	(9.87)	(8.85)	(1.01)	(0.85)	(0.21)
Log GDP/cap host	0.75***	0.75***	0.46***	0.54***	0.46***	–1.23***
	(14.69)	(14.40)	(4.54)	(6.17)	(4.61)	(5.30)
Inst. quality parent				1.45***	1.51***	1.74***
				(9.44)	(9.80)	(9.56)
Inst. quality host				0.29***	0.37***	1.45***
				(3.84)	(4.30)	(9.21)
Constant	–37.40***	–37.37***	–38.12***	–25.25***	–24.47***	–13.92***
	(20.38)	(20.25)	(15.80)	(11.94)	(11.49)	(4.54)
Adjusted R^2	0.56	0.56	0.57	0.57	0.57	0.60
Observations	2629	2591	1423	2629	2591	1423
log likelihood	–5031	–4966	–2751	–4981	–4911	–2684

Absolute robust *t*-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%. Year dummies included (not shown).

Table 5D.2 – Effects GDP and GDP per capita for different specifications of gravity equation and sample sizes, multilevel

	Sample N=1423 (skilled-labour abundance)		Sample N=2591 (human capital)	
	Basic gravity model	Gravity model incl. GDP per capita	Basic gravity model	Gravity model incl. GDP per capita
	(1)	(2)	(3)	(4)
Log GDP parent	5.01***	1.08***	3.75***	0.94***
	(17.49)	(5.15)	(21.95)	(4.34)
Log GDP host	0.81***	0.47***	0.74***	0.45***
	(5.92)	(2.70)	(7.50)	(4.22)
Log GDP per capita parent		4.19***		3.00***
		(9.48)		(9.00)
Log GDP per capita host		1.09***		1.09***
		(3.33)		(6.32)
Log Distance	–0.90***	–0.91***	–0.89***	–0.90***
	(7.41)	(7.52)	(10.15)	(10.31)
Language dummy	0.61	0.54	0.73***	0.74***
	(1.36)	(1.60)	(2.88)	(2.88)
Colonial dummy	0.60	0.64	0.48	0.48
	(1.36)	(1.45)	(1.57)	(1.57)
Constant	–61.90	127.88**	–78.61**	78.64**
	(0.93)	(2.21)	(2.39)	(2.17)
Observations	1423	1423	2591	2591
log likelihood	–1753	–1743	–3206	–3171

Absolute t-statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.
The coefficients relate to within-country (pair) changes.
Cluster means of explanatory variables are included to ensure consistent estimators (not shown). See Table 5.5 which cluster means have been used in the multilevel analysis.

Table 5D.3 – Effects institutional quality for different specifications of gravity equation and sample sizes, multilevel

	Sample N=1423 (skilled-labour abundance)			Sample N=2591 (human capital)		
Log GDP parent	4.98***	1.49***	1.62***	3.70***	1.37***	1.41***
	(17.42)	(6.66)	(6.98)	(21.61)	(5.55)	(5.66)
Log GDP host	0.82***	0.49**	0.50**	0.77***	0.38**	0.38***
	(5.79)	(2.52)	(2.58)	(7.56)	(3.19)	(3.17)
Log Distance	–0.91***	–0.92***	–0.93***	–0.89***	–0.91***	–0.91***
	(7.50)	(7.60)	(7.63)	(10.25)	(10.38)	(10.36)
Language dummy	0.59*	0.54	0.52	0.74***	0.73***	0.73***
	(1.71)	(1.58)	(1.52)	(2.92)	(2.85)	(2.85)
Colonial dummy	0.61	0.64	0.66	0.47	0.49	0.48
	(1.37)	(1.42)	(1.48)	(1.54)	(1.58)	(1.56)
Institutional quality parent	10.99***	2.58***	–0.52	7.57***	2.34***	2.32***
	(3.79)	(3.25)	(0.54)	(4.50)	(2.77)	(2.80)
Institutional quality host	0.29	0.10	0.24	0.66**	–0.41	–0.44
	(0.95)	(0.23)	(0.54)	(2.49)	(1.37)	(1.33)
Log GDP per capita parent		3.67***	2.13***		2.39***	2.34***
		(7.83)	(4.06)		(6.39)	(6.27)
Log GDP per capita host		1.04**	0.54		1.28***	1.28***
		(2.78)	(1.38)		(5.99)	(5.86)
Log Skills parent			3.52***			1.34
			(6.25)			(0.77)
Log Skills host			0.17			0.11
			(0.53)			(0.18)
Constant	–255.33***	67.22	103.54	–144.20***	21.68	2.78
	(3.95)	(0.80)	(1.26)	(5.76)	(0.44)	(0.05)
log likelihood	–1739	–1739	–1718	–3194	–3166	–3166

Absolute t-statistics in parentheses. The coefficients relate to within-country (pair) changes. Cluster means of explanatory variables are included to ensure consistent estimators (not shown). See Table 5.5 which cluster means have been used in the multilevel analysis.

6

FDI and Trade: the Role of Multiple Dimensions of Distance[111]

6.1. Introduction

To serve foreign markets, firms can either export or set up a local subsidiary through horizontal FDI. Brainard (1997) models this decision of firms as a trade-off between achieving proximity to local markets, and concentrating production in space so as to exploit economies of scale. FDI substitutes for trade if distance between countries is large, while exports become more important if scale economies in production are large. This chapter aims to contribute to the discussion on the trade-off between exports and FDI by empirically investigating how distance affects the volume of bilateral sales and its composition in terms of trade and FDI. In the models in Brainard (1997) and Helpman et al. (2004) distance is measured first and foremost in terms of transport costs and trade barriers. This chapter considers different dimensions of distance suggested by the literature. Our approach explicitly takes into account intangible barriers related to cultural and institutional differences. Unlike the mechanisms described by the proximity-

[111] This chapter is based on Lankhuizen et al. (2009).

concentration hypothesis, these 'intangible' barriers can affect the costs related to FDI as well as trade, as pointed out in more detail in the literature review in Section 3.5.3.

The chapter is organised as follows. Section 6.2 describes the model setup. Section 6.3 describes the data. In Section 6.4 we present and discuss the regression results. In Section 6.5 we check the robustness of our results using multilevel estimation. Section 6.6 concludes.

6.2. A gravity model of international transactions

We use the following basic gravity equation to study patterns of bilateral foreign sales (sum of exports and sales related to FDI) from exporter *e* to importer *i*:

$$\ln(F_{t(ei)}) = \beta_0 + \beta_1 \ln(GDP_{t(e)}) + \beta_2 \ln(GDP_{t(i)}) + \beta_3 \ln(GDPcap_{t(e)}) + \beta_4 \ln(GDPcap_{t(i)}) + \beta_5 \ln dist_{t(ei)} + \varepsilon_{t(ei)}. \tag{6.1}$$

F_{ei} denotes bilateral sales. The size of the origin and destination markets is reflected by the gross domestic products of the countries of origin and destination (*GDP*), and by per capita incomes (*GDPcap*). Including GDP per capita is based on the stylized fact in international trade that "high-income countries trade disproportionately more with all trading partners and not just among themselves, while low-income countries trade less" (Deardorff, 1998, p.16).

The focus in this chapter is on four dimensions of distance ($dist_{ei}$). We specify distance in terms of geography, culture and institutions, and distance caused by import tariffs. To measure cultural and institutional distance, we apply an index of distance that was developed for these purposes and first applied by Kogut and Singh (1988).[112] In addition to cultural distance, we control for a shared cultural background by including a dummy variable that indicates whether countries share a common language. Apart from a direct measure of institutional distance, we also include the quality levels of the institutional environment in the country of origin and the country of destination. Transaction costs depend on both the level of institutional quality (e.g., contract enforceability and expropriation risk) in both countries and the bilateral distance (affecting mutual understanding of and familiarity with informal solutions to governance

[112] The index is defined as: $D_{i,j} = \frac{1}{K}\sum_{k=1}^{K}\frac{\left(I_{i,k} - I_{j,k}\right)^2}{V_k}$. Here $D_{i,j}$ is the measure of distance between country *i* and country *j*, *K* is the number of indicators of culture/institutional quality distinguished (indexed by *k*), $I_{i,k}$ is country *i*'s score with respect to indicator *k*, and V_k the variance of indicator *k* over all countries in the sample.

problems). The set of control variables also includes a dummy variable that indicates whether or not countries are adjacent in space. We also include year dummies to control for global trends.

We are interested in the effect of the different dimensions of transactional distance on the volume of bilateral sales and on the trade-off between its components. Therefore, we distinguish two bilateral measures: the volume of bilateral sales (sum of exports and FDI-sales) and FDI intensity (share of FDI-sales in bilateral sales). To describe the volume of bilateral sales, we estimate equation (1) using ordinary least squares (OLS). For FDI intensity as dependent variable, we need to transform the gravity equation, because (by definition) FDI intensity ranges between zero and one. We assume that FDI intensity follows a continuous logistic function between zero and one, given by:

$$S_{ei} = \frac{1}{1 + e^{-\sum \beta_j X_j + \varepsilon_{ei}}} \tag{6.2}$$

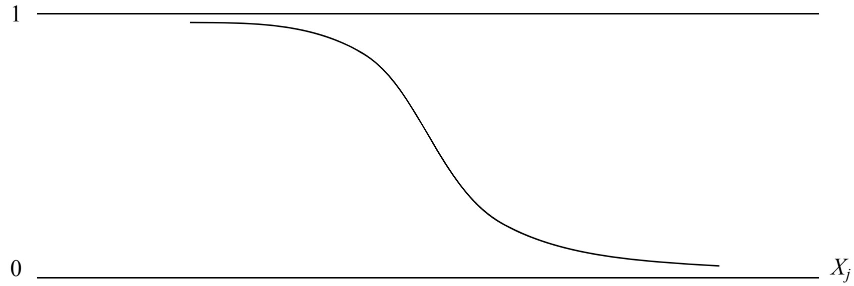
where S_{ei} stands for the share of FDI-sales in bilateral sales, and the X_j's refer to the same set of explanatory variables as in equation (1). Due to its functional form, the (deterministic) expected FDI intensity of bilateral sales and the random outcome are bounded between zero and one as well. For this functional form, the effect of a continuous explanatory variable on FDI intensity is illustrated graphically in Figure 6.1. Panel (a) shows the effect of changes in variables whose coefficient β is negative. An increase in X reduces the FDI intensity. On the other hand, when β is positive, an increase in X raises FDI intensity as illustrated in panel (b). We estimate equation (6.2) using non-linear least squares (NLS).

6.3. Data

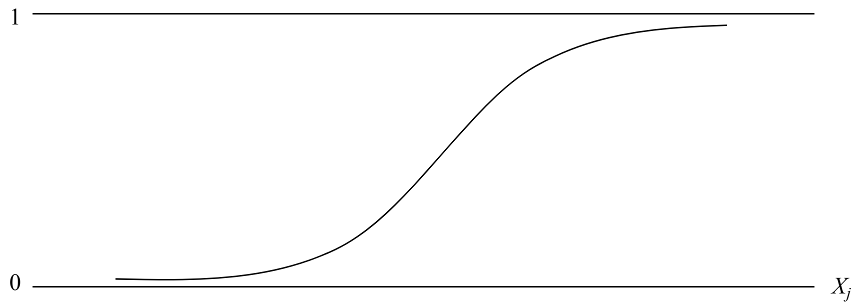
The OECD data on FDI represent FDI stocks. To analyse the relative importance of FDI versus exports in bilateral foreign sales, we use a proxy for sales associated with FDI.[113] The proxy is derived by transforming FDI stocks into sales using capital-output ratios. Data on capital intensity are from the Penn World Tables. Export data are from the UN COMTRADE database for bilateral trade. The data sample includes exports and FDI between OECD countries as well as exports and FDI from OECD countries to major non-

[113] Comparison of data on affiliate sales from the BEA and our measures of FDI-related sales for the U.S. shows high levels of correlation: 0.99 or 0.90 in the case inward FDI sales, and 0.85 or 0.92 for outward sales (the differences depend on whether the capital-output ratio of the parent country or the host country is used). The calculation is based on data for 1990.

Figure 6.1. Illustration of the FDI-intensity function



Panel (a): β<0



Panel (b): β>0

OECD countries for the period 1984–1990.[114]

The source of data for GDP and GDP per capita is the Penn World Tables Mark 5.6, as before. We use distance in miles between capital cities for geographical distance between countries. The data for the indicators of cultural distance are from Hofstede (2001).[115] Hofstede (1980, 2001) has developed a set of variables that reflect national cultures in terms of norms and values. These variables are: masculinity/femininity; uncertainty avoidance; individualism/collectivism; and power distance. Each is constructed on the basis of principal components analysis, and intends to reflect the stance of a distinct set of work-related norms and values in national cultures. Institutional

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[114] We have omitted the years 1982-1983 and 1991-1992 from our sample due to a lack of observations. Although FDI has increased rapidly in the last two decades in particular, we may assume that the (marginal) effects of distance on trade and FDI are more or less constant over time. For instance, the effect of (geographic) distance on trade is shown to be persistent over time despite falling costs of transport and communication (see, e.g., Disdier and Head, 2008, Linders, 2006).

[115] Supplemented with additional countries (Linders et al., 2005).

data are from Kaufmann et al. (2005). Kaufmann et al. (2005) have constructed six indicators of perceived institutional quality on the basis of principal components analysis. These indicators are: voice and accountability; political stability; government effectiveness; regulatory quality; rule of law; control of corruption. The institutional quality score of a country is calculated by taking the simple average of the scores across all six governance indicators. Data on common borders and a common language are from CEPII. As an indicator of tangible trade barriers, we use trade-weighted applied tariffs from the WITS data set. Further information on the variables used in this chapter is presented in the Data Appendix in the back of this study. Descriptive statistics and correlations for our data sample are presented in Appendix 6A.

6.4. Empirical results

This section presents the results from estimating gravity equations for bilateral foreign sales and for the share of FDI-sales. First we discuss the results for a standard gravity model. Then we turn to the multiple dimensions of distance.

6.4.1. The gravity model of total bilateral sales and FDI intensity

The first specification in Table 6.1 presents the results for the basic model of bilateral sales, given in equation (1). The results indicate that the patterns of bilateral sales are explained fairly well by the gravity equation. The effect size for the traditional gravity model variables, GDP and geographical distance, is comparable to the standard findings in empirical studies of bilateral trade patterns (see Frankel, 1997, Disdier and Head, 2008, Linders et al., 2008). Total sales increase with both the GDP of the origin and the destination country, and fall with geographical distance. Following the stylized fact that high-income countries trade more (Deardorff, 1998), we included GDP per capita of the origin and destination countries in the gravity equation for total bilateral sales. The statement by Deardorff receives some empirical support from our estimates of the basic model. Except for per capita income of the country of origin, all variables in the base model are highly statistically significant.

The results for FDI intensity, given in column (2), show the rich possibilities for interpretation that follow from investigating the composition of bilateral sales. First, we find clear evidence of a conventional proximity-concentration trade-off in geographical terms. FDI intensity increases with geographical distance and this effect is highly statistically significant. Regarding the other traditional gravity equation variables, we can see that the country of origin is relatively more involved in FDI-related sales if its GDP level is higher. In contrast, the GDP in the destination country does not appear to affect

Table 6.1. Estimation results total bilateral sales and FDI intensity

	Basic model		Culture, institutions and bilateral tariffs		Fixed effects
	Log Total sales	FDI intensity	Log Total sales	FDI intensity	Log Total sales
	(1)	(2)	(3)	(4)	(5)
Log GDP exp	0.90***	0.14***	1.02***	0.36***	
	(37.99)	(4.72)	(40.36)	(10.35)	
Log GDP imp	0.76***	0.02	0.86***	0.02	
	(35.12)	(0.74)	(36.02)	(0.47)	
Log GDP/cap exp	0.10	1.62***	–1.23***	–0.44	
	(0.90)	(8.56)	(7.92)	(1.64)	
Log GDP/cap imp	0.72***	0.17***	–0.03	0.08	
	(18.06)	(3.28)	(0.37)	(0.65)	
Log Distance	–0.70***	0.14***	–0.59***	0.10***	–0.68***
	(29.83)	(4.65)	(23.35)	(2.84)	(21.55)
Language dummy			0.51***	0.48***	0.46***
			(6.79)	(5.46)	(6.75)
Adjacency			0.42***	–0.51***	0.41***
			(5.24)	(4.48)	(5.92)
Cultural distance			–0.03*	–0.14***	–0.09***
			(1.79)	(4.93)	(5.19)
Inst. quality exp			0.83***	1.53***	
			(8.90)	(8.31)	
Inst. quality imp			0.63***	0.29**	
			(7.13)	(2.13)	
Inst. distance			0.02	0.04	0.10**
			(0.53)	(0.75)	(2.39)
Log(1+Tariff)			–3.79***	2.54**	–4.80***
			(5.25)	(2.13)	(3.59)
Constant	–15.29***	–20.59***	–1.62	–5.60**	12.31***
	(14.29)	(11.62)	(1.27)	(2.70)	(26.01)
Adjusted R^2	0.74	0.71	0.80	0.76	0.89
Observations	1145	1145	1145	1145	1145

Absolute robust *t*-statistics in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%.
Note: Specifications for FDI intensity are estimated using nonlinear least squares. Specifications for total sales are estimated with standard OLS.
Columns 1–4: year dummies included (not shown). Column 5 includes importer-year and exporter-year specific dummies. Data cover the period 1984–1990.

the composition of bilateral sales.[116] A possible explanation is that the probability of highly productive firms is higher in larger economies, because of scale advantages at the firm level that can be exploited on the domestic market. Because highly productive companies are more likely to engage in FDI (see Helpman et al., 2004), FDI would respond elastically to GDP in the parent country. A similar reasoning may explain why GDP per capita in the parent country is important in explaining the trade-off between FDI and exports. If only the most productive of firms that engage in international transactions become established as multinational firms, a high average income and productivity is likely to yield relatively more FDI-related sales.

6.4.2. The multiple dimensions of distance

We now turn to the main question in this chapter, i.e. how transaction costs that arise from different dimensions of distance affect the volume and composition of bilateral sales. Column (3) in Table 6.1 presents the estimation results for total bilateral sales volumes.[117] Column (4) reports the outcomes for FDI intensity. Specification (5) includes year-specific fixed effects for country of origin and country of destination and is included to assess the robustness for a number of our dimensions of distance. The fixed-effects specification is in line with theoretical concerns about omitted variables in the gravity equation for exports (see Feenstra, 2004). The disadvantage, though, is that country-specific regressors cannot be included because of the fixed effects. This implies, for example, that we cannot assess the effect of the level of institutional quality in both origin and destination.

As shown in column (3), the gravity equation again performs quite well in explaining total bilateral foreign sales. The sum of exports and FDI sales depends negatively on geographical distance, as before, although the magnitude of distance decay falls when we add other dimensions of proximity or distance affecting transactions. The sign of the effect of most dimensions of distance (language, adjacency, cultural distance, institutional quality and import tariffs) is as one would expect, given the impact we *a-priori* believe they have on transaction costs.

Bilateral sales decrease with cultural distance.[118] Although the effect of distance in cultural norms and values is statistically significant only at the 10% level in specification

[116] These findings are consistent with the existing literature on FDI. See, for example, Bergstrand and Egger (2007, p. 296) who note that 'typical FDI gravity equation estimates find home country GDP elasticities significantly larger than host country GDP elasticities'.

[117] We have also disentangled bilateral sales, and estimated gravity equations for exports and FDI-sales. The results are presented separately in Appendix 6B. Because we have used data on FDI stocks to compute FDI-sales, we also present gravity equation estimates for FDI stocks there.

[118] Cultural distance is estimated to have a positive effect on exports and a negative effect on FDI (see Table 6B.1 in Appendix 6B). These results suggest that cultural distance is of particular importance to FDI and that firms substitute exports for FDI when cultural distance increases. Nevertheless, in a specification with full

(3), the estimate is statistically more significant in the fixed-effects regression. Next, we turn to institutional quality and institutional distance. Institutional quality positively and significantly affects bilateral interaction. This reflects that better institutions reduce the uncertainty surrounding transactions, thereby acting to lower transaction costs. The estimated effect of institutional distance does not support our ex-ante expectations, neither in the extended model (3), nor in the fixed effects specification (5). We would expect that bilateral sales to increase if institutional environments between countries are more similar. In the fixed-effects estimation, the effect of institutional distance on bilateral sales is significantly positive. This finding is contrary to estimates for bilateral trade previously found in the literature, and may be related to the nature of the sample in our analysis. The set of origin countries only consists of 12 OECD countries, while destination countries include both OECD and non-OECD countries. Low institutional distance applies to trade between OECD countries, and high institutional distance to trade between OECD and non-OECD countries. This explains why institutional distance and destination country institutional quality are highly correlated in our sample (see Table 6A.2). Since flows originating from countries with relatively low institutional quality are lacking from this sample, it may be difficult to capture the effect of institutional distance (as separate from institutional quality).

The results in column (3) of Table 6.1 seem at odds with the stylized fact on the role of GDP per capita in bilateral sales. Per capita income of the origin country has a negative and significant effect on bilateral sales. This suggests that more developed countries engage less in outward bilateral sales, all else equal. The level of development of the destination country has no significant impact on bilateral sales. Despite the stylized facts quoted by Deardorff, the theoretical literature that underpins the gravity equation does not predict any relation between the level of development and total bilateral export. In fact, GDP per capita may proxy for omitted variables such as institutional quality that are highly correlated to it. It is quite common to find an insignificant or negative effect of per capita income on bilateral trade once institutional effectiveness is controlled for (Anderson and Marcouiller, 2002, De Groot et al., 2004). A negative effect may also reflect that, when countries become wealthier, the share of total expenditure devoted to traded goods falls, because the structure of production and consumption shifts from commodities towards services.[119]

With respect to FDI intensity, we see that the extension into multiple dimensions of distance supplements the conventional proximity-concentration trade off. The relative importance of FDI increases with geographical distance, as before. The results also

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country-specific fixed effects, the effect of cultural distance is negative for both exports and FDI alike. Thus, the results no longer provide evidence for the substitution (in absolute terms) of FDI by exports. Rather, they are consistent with a trade-off in relative terms.

[119] As FDI stocks include the service sector, this argument cannot explain why FDI is negatively related to income per capita of the parent country, all else equal. This result remains puzzling in a setting of horizontal FDI.

strongly indicate a shift from exports to FDI if tariff barriers increase. This supports the conventional proximity-concentration trade off.[120]

The results furthermore indicate that the relative importance of FDI sales increases as the quality of institutions in both the parent and host country increases. The effect of institutional quality of the parent country is particularly large. This may reflect that only the most productive firms engage in FDI which are likely to be found only in high-quality institutional environments (Helpman et al., 2004).

As a robustness check, we also estimated specifications including absolute per capita GDP differentials to control for factor-proportions and preference differences (cf. Brainard, 1997). Our results suggest that countries with similar levels of income trade and invest more amongst each other. This provides support for the Linder (1961) hypothesis that similarity in income promotes bilateral sales. However, the support for this result is statistically weak. Per capita GDP similarities turn out to be relatively more important for FDI, a result that mirrors previous findings in Brainard (1997). However, the statistical significance of this finding is low. The results do not affect other findings qualitatively, and are available on request.

Discussion

We find that different dimensions of distance affect exports and FDI differently. As a result, some destinations are served relatively intensively through exports and others more through sales from FDI. The share of FDI sales increases with geographical distance. As geographical distance increases so do transport costs. Total foreign sales (exports and sales related to FDI) fall with geographical distance, but it constitutes a larger cost for exports than FDI. On the other hand, 'soft' barriers, i.e. language, culture and institutions, are particularly important for FDI. This can be explained from the fact that local presence entails a relatively deep involvement with and exposure to local cultures and institutions. Also, the demands in terms of language are higher for operating a plant in a foreign market compared to exporting.

To interpret the economic significance for the FDI intensity of the coefficients in column (4) in Table 6.1, we use typical values of the explanatory variables in the sample. Table 6.2 gives the expected value of the FDI intensity for the minimum and maximum values, the sample mean and the mean plus (minus) one standard deviation for each

[120] The results in Appendix 6B, where export and FDI sales are disentangled, show a relative trade-off; both FDI sales and exports negatively depend on distance and tariffs, but the elasticity is higher for trade. In fact, FDI sales only show a statistically weak decline if tariffs rise, indicating a possibly substantial substitution of exports by FDI sales in the face of high tariff barriers (see, e.g. Carr et al., 2001, Markusen, 2002). For comparison, Brainard (1997) finds a positive coefficient of trade barriers on the level of affiliate sales, even though she notes that, strictly speaking, the proximity-concentration hypothesis applies to shares rather than to levels of affiliate sales and trade. Carr et al. (2001) also predict and find a positive effect of trade costs in the host country on the level of affiliate sales.

Table 6.2. Economic significance of parameter estimates FDI intensity

	Min.	–1 Std. Dev.	Mean	+1 Std. Dev.	Max.
Log GDP exporter	0.18	0.25	0.34	0.44	0.51
Log GDP importer	0.33	0.33	0.34	0.34	0.35
Log GDP per capita exporter	0.44	0.36	0.34	0.32	0.31
Log GDP per capita importer	0.30	0.33	0.34	0.35	0.35
Log Distance	0.27	0.31	0.34	0.36	0.37
Language dummy	0.32	0.30	0.34	0.38	0.43
Adjacency	0.34	0.37	0.34	0.31	0.24
Cultural distance	0.41	0.38	0.34	0.29	0.20
Institutional quality exporter	0.12	0.23	0.34	0.46	0.49
Institutional quality importer	0.24	0.30	0.34	0.38	0.38
Institutional distance	0.33	0.33	0.34	0.35	0.38
Log(1+Tariff)	0.32	0.31	0.34	0.37	0.51

Note: the numbers indicate the value of FDI intensity for typical values of the explanatory variables in our sample, fixing all other variables to their sample mean. 'Min.' and 'Max.' denote the minimum and maximum values in the sample; '–1 (+1) Std. Dev.' denote –1 (+1) standard deviation from the sample mean.

of the explanatory variables, fixing all other explanatory variables to their sample mean. Our results illustrate that FDI does not merely substitute for trade when transport costs and trade barriers are high: FDI sales incur costs of their own. Table 3 indicates that, for example, increasing cultural distance by one standard deviation from its sample mean *ceteris paribus* reduces the share of FDI sales in total foreign sales (FDI plus exports) by 5 percentage points. Similarly, an increase in institutional quality of the parent and the host country by one standard deviation from their sample mean increases the share of FDI sales by 12 and 4 percentage points, respectively. For comparison, the effects of our 'soft' dimensions of transactional distance on the trade-off between exports and FDI are comparable to, and sometimes more substantial, than the effects of the traditional proximity-concentration control variables. An increase in geographical distance by one standard deviation from its sample mean increases the share of FDI sales by 2 percentage points. A one standard deviation increase in bilateral import tariffs increases the share of FDI sales by 3 percentage points. For comparison of their quantitative effects on FDI intensity, we can express changes in intangible barriers as tariff equivalents (similar to Anderson and Van Wincoop, 2004). A decrease in cultural distance of one standard deviation is equivalent to an 8 percentage point increase of the average bilateral tariff. The tariff equivalents of an increase in institutional quality of the parent and the host country of one standard deviation are 22 and 7 percentage points, respectively.

6.5. Additional robustness analysis

In this section, we check the robustness of our results. We start by using multilevel estimation. Regarding total foreign sales, we perform a cross-classified multilevel analysis, as we have done throughout Part II.[121] We use a different method for the estimation of the FDI intensity. The logistic function cannot be estimated with standard multilevel programmes.[122] A solution is to resort to Bayesian analysis. However, Bayesian analysis is based on a rather different philosophy as regards the nature of the estimated parameters than classical 'frequentist' analysis. The latter views parameters as unknown constants, whereas the former views them as random, i.e., uncertain, outcomes.[123] The frequentist approach is the one that is commonly used in the empirical trade literature. Bayesian analysis is beyond the context of this study. In order to account for clustering in the estimation of the FDI intensity after all, we estimate the equation with nonlinear least squares and cluster-robust standard errors. Table 6.3 gives the results.

Column (1) gives the results of the multilevel analysis for total sales with parent, host and parent-host random effects.[124] Cluster means are included (but not shown) to ensure unbiased coefficients of the explanatory variables.[125] We find that our results for total sales are largely robust to the multilevel estimation. Coefficients by and large have the expected sign.[126] We note that the effect of GDP per capita is now positive. Furthermore, although significance levels are generally reduced compared to OLS, most variables remain statistically significant. The only exception in this respect is bilateral tariffs.

Columns (2) – (4) give the results for the estimation of FDI intensity with cluster-robust standard errors. As explained in Chapter 4, we can only use one cluster variable at a time. Column (2) gives the results with clustering by parent, column (3) with clustering by host country, and column (4) with clustering by parent-host combinations. Once again, significance levels across the board are lower when clustering of the data is taken into account. In fact, institutional quality of the host and geographic distance are no longer significant statistically, regardless of the cluster variable. The latter indicates that, with cluster-robust standard errors, the statistical evidence in favour of a trade-off between FDI and exports in the face of geographic distance is weak.

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[121] The multilevel results for exports, FDI stocks and FDI sales are presented in Table 6B.2 in Appendix 6B.
[122] Multilevel models are computationally complex as it is. Multilevel analysis is mostly applied to linear models (see, e.g., Raudenbush and Bryk, 2002).
[123] Bayesian analysis has been used by, e.g., Fernandez et al. (2001) to investigate the issue of model uncertainty in cross-country growth regressions.
[124] Table 6A.3 in the Appendix 6A gives the estimates of the within parent-host combination variance as well as the between variances (parent, host and parent-host combinations) for two different baseline models. All three between-variances are significant.
[125] We applied the same procedure for including cluster means (see Chapters 4 and 5).
[126] Institutional quality of the host has a negative effect on total sales, but this is most likely the result of collinearity between institutional quality and GDP per capita.

Table 6.3. Sensitivity analysis: multilevel analysis and cluster-robust standard errors

	Total sales	FDI intensity		
	(1)	(2)	(3)	(4)
Log GDP exporter	1.46***	0.36***	0.36***	0.36***
	(9.99)	(4.07)	(6.17)	(4.64)
Log GDP importer	0.78***	0.02	0.02	0.02
	(10.37)	(0.23)	(0.11)	(0.20)
Log GDP cap exporter	0.57**	–0.44	–0.44	–0.44
	(2.62)	(0.75)	(0.89)	(0.74)
Log GDP cap importer	1.58***	0.08	0.08	0.08
	(11.05)	(0.47)	(0.17)	(0.28)
Log Distance	–0.80***	0.10	0.10	0.10
	(14.17)	(1.29)	(1.20)	(1.23)
Language dummy	0.49***	0.48***	0.48**	0.48***
	(3.40)	(3.53)	(2.07)	(2.31)
Adjacency	0.36**	–0.51***	–0.51**	–0.51***
	(2.09)	(2.71)	(2.11)	(2.01)
Cultural distance	–0.09**	–0.14**	–0.14**	–0.14**
	(2.62)	(2.08)	(2.16)	(2.02)
Institutional quality exporter	1.29***	1.53***	1.53***	1.53***
	(3.06)	(3.48)	(5.18)	(3.49)
Institutional quality importer	–0.08	0.29	0.29	0.29
	(0.39)	(1.11)	(0.53)	(0.90)
Inst. distance	0.12*	0.04	0.04	0.04
	(1.68)	(0.51)	(0.28)	(0.35)
Log(1+Tariff)	–1.34	2.54***	2.54	2.54
	(0.73)	(2.78)	(0.54)	(0.96)
Constant	–57.48***	–5.60	–5.60**	–5.60
	(3.16)	(1.24)	(1.27)	(1.24)
Observations	1145	1145	1145	1145
log likelihood	–192			

Column 1: multilevel analysis with parent, host and parent-host random effects. The coefficients in column (1) relate to within-country (pair) changes. Cluster means of explanatory variables are included to ensure consistent estimators (not shown). The following cluster means are included: GDP and GDP per capita of parent by host country, GDP and GDP per capita of host by parent country, distance by host country, language and adjacency by parent and host country, and cultural distance by parent and host country.
Columns 2–4: non-linear regression with cluster-robust standard errors. Column (2) gives the results from clustering by parent, column (3) from clustering by host country, column (4) from clustering by parent-host combinations. Year dummies included in columns 2–4 (not shown).
Absolute *t* statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

The evidence for tariffs depends on which cluster variable is used. At the same time, our results still support the relative importance for FDI of a common language, institutional quality of the parent and cultural proximity. The same is true for the relative importance of adjacency for exports.

Next, we examine the specifications of total sales and FDI intensity using purely cross-sectional data. This is done by averaging the variables over time. The results are given in Table 6.4. The table indicates that *t*-statistics (standard errors) of all variables are generally lower (higher) in the cross-section estimation. In a few cases, coefficients are no longer statistically significant.[127] Nevertheless, the sign patterns and coefficient sizes are qualitatively robust.

6.6. Conclusion

To serve foreign markets, firms can either export or set up a local subsidiary through horizontal FDI. According to the proximity-concentration trade-off (Brainard, 1997, Helpman et al., 2004) local sales associated with FDI increase relative to exports the higher are transport costs and trade barriers and the lower are investment barriers and scale economies at the plant level relative to the corporate level.

In this chapter, we extend the framework for analysing the trade-off between exports and FDI empirically. We investigate the effect of various dimensions of distance on the composition of total bilateral interaction, *viz.* geographical distance and distance in economic terms due to tangible trade barriers such as tariffs and intangible barriers such as cultural and institutional differences between countries. Furthermore, unlike the conventional proximity-concentration trade-off our approach explicitly takes into account that intangible barriers affect the fixed and variable costs related to FDI as well and may affect the trade-off between exports and FDI differently.

We show that different dimensions of distance affect exports and FDI differently. First, there is clear evidence in support of a conventional proximity-concentration trade-off. The share of FDI sales increases with both geographical distance and import tariffs. On the other hand, this chapter illustrates that FDI does not merely substitute for trade when transport costs and trade barriers are high. It incurs costs of its own. These costs are primarily of an intangible nature. The share of FDI in total bilateral sales decreases with language differences and cultural distance, and increases with institutional quality in both the parent and host country. Hence, 'soft' barriers are particularly important for FDI. Our results, though, do not offer robust support for a negative effect of institutional distance on either trade or FDI.

[127] In particular, this pertains to the effect of cultural distance on total sales and the effects of geographical distance, institutional quality of the importer and bilateral tariffs on FDI intensity.

Table 6.4. Results from cross-section

	Culture, institutions and bilateral tariffs	
	Log Total sales	FDI intensity
	(1)	(2)
Log GDP exporter	0.95***	0.41***
	(18.03)	(5.72)
Log GDP importer	0.87***	0.03
	(16.33)	(0.38)
Log GDP per capita exporter	–0.97***	–0.33
	(2.99)	(0.54)
Log GDP per capita importer	–0.12	0.07
	(0.66)	(0.24)
Log Distance	–0.60***	0.06
	(10.69)	(0.75)
Language dummy	0.39**	0.48**
	(2.27)	(2.47)
Adjacency	0.50***	–0.51**
	(2.78)	(2.03)
Cultural distance	–0.05	–0.15**
	(1.40)	(2.31)
Institutional quality exporter	0.79***	1.61***
	(3.71)	(3.59)
Institutional quality importer	0.77***	0.35
	(4.26)	(1.12)
Institutional distance	0.05	0.05
	(0.84)	(0.38)
Log(1+Tariff)	–3.56**	3.69
	(2.33)	(1.30)
Constant	–2.23	–7.25
	(0.83)	(1.48)
Observations	223	223
Adjusted R^2	0.81	0.75

Notes: Absolute robust *t*-statistics in parentheses. Starts indicate statistical significance: * significant at 10%, ** significant at 5%, *** significant at 1%.

Finally, our results indicate that larger economies engage relatively more in outward FDI, while the size of the foreign market affects exports and FDI by and large equally. This may be interpreted to provide support for the argument that only relatively high-productivity firms are active on the export market and the most productive firms become multinational firms by investing abroad. On the other hand, per capita income, as a measure of productivity, does not have a statistically positive effect on the FDI intensity of bilateral sales. This reflects that high-income countries tend to have less bilateral interaction both inward and outward, once we control for the effect of institutional quality.

Appendix 6A. Data

Table 6A.1 gives the summary statistics for the estimation sample.

Table 6A.1 – Descriptive statistics

	Mean	Std. Dev.	Min	Max	Obs.
Log Exports	14.12	1.61	5.74	18.39	1145
Log FDI stock	6.25	2.40	–1.18	11.92	1145
Log FDI sales	6.17	2.41	–1.26	11.98	1145
Log total foreign sales	7.75	1.63	2.59	12.44	1145
FDI intensity	0.34	0.25	0.00	1.00	1145
Log GDP exporter	13.31	1.19	11.03	15.32	1145
Log GDP importer	12.25	1.25	10.13	15.32	1145
Log GDP per capita exporter	9.50	0.22	8.53	9.80	1145
Log GDP per capita importer	9.12	0.63	6.92	9.80	1145
Log absolute diff. GDP per capita	0.51	0.57	0.00	2.78	1145
Log Distance	8.25	1.14	5.16	9.88	1145
Language dummy	0.18	0.38	0.00	1.00	1145
Adjacency	0.07	0.26	0.00	1.00	1145
Cultural distance	2.20	1.47	0.02	7.44	1145
Institutional quality exporter	1.47	0.35	0.59	1.90	1145
Institutional quality importer	1.25	0.65	–0.46	1.93	1145
Institutional distance	0.74	1.04	0.02	5.43	1145
Log(1+Tariff)	0.03	0.05	0.00	0.31	1145

Table 6A.2 gives the correlation matrix for the data used in the estimation samples.

Table 6A.2 – Correlation matrix (*N*=1145)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1. Log Exports	1													
2. Log FDI stock	0.69	1												
3. Log FDI sales	0.68	0.99	1											
4. Log total foreign sales	0.93	0.86	0.86	1										
5. FDI intensity	0.02	0.67	0.69	0.35	1									
6. Log GDP exporter	0.28	0.41	0.42	0.36	0.31	1								
7. Log GDP importer	0.51	0.31	0.33	0.50	0.02	–0.10	1							
8. Log GDP cap exp	0.06	0.33	0.33	0.15	0.36	0.36	–0.08	1						
9. Log GDP cap imp	0.38	0.32	0.25	0.37	0.02	–0.20	0.19	0.01	1					
10. Log abs diff. GDPcap	–0.29	–0.23	–0.17	–0.27	0.03	0.25	–0.06	0.06	–0.91	1				
11. Log Distance	–0.32	–0.11	–0.08	–0.23	0.22	0.36	0.14	0.12	–0.21	0.31	1			
12. Language dummy	0.10	0.28	0.28	0.19	0.33	0.06	0.03	0.22	–0.02	0.09	0.07	1		
13.Adjacency	0.34	0.20	0.19	0.30	–0.09	–0.04	0.03	0.02	0.13	–0.15	–0.43	0.24	1	
14. Cultural distance	–0.12	–0.26	–0.25	–0.18	–0.23	–0.03	–0.08	–0.08	–0.20	0.22	0.00	–0.41	–0.23	1
15. Inst. quality exp	–0.05	0.21	0.20	0.03	0.28	–0.22	–0.01	0.58	0.07	–0.06	–0.17	0.20	0.00	0.07
16. Instit quality imp	0.23	0.24	0.19	0.23	0.07	–0.15	–0.12	0.01	0.81	–0.75	–0.22	0.09	0.06	–0.17
17. Instit distance	–0.19	–0.19	–0.15	–0.19	–0.06	0.12	0.07	–0.01	–0.61	0.66	0.16	–0.02	–0.05	0.28
18. Log(1+Tariff)	–0.28	–0.19	–0.14	–0.23	0.07	0.20	0.14	–0.05	–0.70	0.70	0.45	0.05	–0.16	0.03

Table 6A.2 – Continued

	(15)	(16)	(17)	(18)
15. Inst. quality exp	1			
16. Instit quality imp	0.06	1		
17. Instit distance	–0.05	–0.78	1	
18. Log(1+Tariff)	–0.17	–0.64	0.54	1

Table 6A.3 gives the estimates of the within parent-host combination variance σ_e^2 as well as the variances between parent countries, host countries and parent-host combinations, σ_{0p}^2, σ_{0h}^2 and σ_{0ph}^2, respectively, for two different baseline models, one including and the other excluding the combination effect c_{0ij}. The estimates of between-country variances can be used to calculate correlation of observations within parent and host countries and parent-host combinations. These intra-class correlations are given in Table 6A.3 as well.

Table 6A.4 shows the increase in *–2LL* of the model for exports, FDI stocks and total sales, respectively, when omitting p_{0i}, h_{0j} or c_{0ij}. These increases are highly significant for a Chi-squared distributed with 1 degree of freedom.

Table 6A.4 – Significance of variances

	Exports	FDI stocks	Total sales
Effect on –2*LL* from omitting:			
Parent random effect	80	170	118
Host random effect	117	114	126
Parent-host random effect	1292	950	1303

Table 6A.3 – Estimates of covariance parameters and intra-class correlations of two baseline models

	Estimates of model [a] $\ln Y_{t(ij)} = b_{00} + p_{0i} + h_{0j} + e_{t(ij)}$			Estimates of model [a] $\ln Y_{t(ij)} = b_{00} + p_{0i} + h_{0j} + c_{0ij} + e_{t(ij)}$		
	Exports	FDI stocks	Total sales	Exports	FDI stocks	Total sales
Level 1						
Individual variance, σ_e^2	0.86	1.45	0.75	0.15	0.37	0.13
Level 2						
Parent country variance, σ_{0p}^2	0.63	3.05	0.89	0.62	3.06	0.90
Host country variance, σ_{0h}^2	1.33	2.26	1.32	1.27	2.08	1.25
Parent-host combination variance, σ_{0ph}^2				0.86	1.48	0.79
Intra-class correlation						
Same parent country ($\sigma_{0p}^2/(\sigma_{0p}^2+\sigma_{0h}^2+\sigma_{0ph}^2+\sigma_e^2)$)				0.15	0.44	0.29
Same host country ($\sigma_{0h}^2/(\sigma_{0p}^2+\sigma_{0h}^2+\sigma_{0ph}^2+\sigma_e^2)$)				0.21	0.30	0.41
Same parent / host combination (($\sigma_{0p}^2+\sigma_{0h}^2+\sigma_{0ph}^2)/(\sigma_{0p}^2+\sigma_{0h}^2+\sigma_{0ph}^2+\sigma_e^2$))				0.95	0.95	0.96
–2LL	3232.46	3850.77	3087.37	1940.34	2900.47	1784.73

[a] $\ln Y_{t(ij)}$ is used to denote the natural logarithm of exports, FDI stocks and total foreign sales. FDI sales are derived from the data on FDI stocks, therefore we do not present separate results for FDI sales here.

Appendix 6B. Background regressions

This appendix presents the background regressions for exports, FDI stocks and FDI sales referred to in the main text. Table 6B.1 gives the results from OLS. Table 6B.2 gives the results of the multilevel analysis with parent, host and parent-host random effects.

For the majority of the variables, the results from the multilevel analysis are qualitatively similar to those from OLS (in the case of institutional distance and bilateral tariffs, similar to the OLS results with fixed effects).[128] This is particularly true for the multiple dimensions of distance.[129] Coefficients that are statistically significant with OLS by and large remain statistically significant in the multilevel model, indicating that the bias from ignoring intra-class correlation in OLS is less consequential.

[128] Somewhat puzzling in Table 6B.2 is the negative effect of importer GDP on exports. This result indicates that, as importer countries become larger over time, they attract fewer exports. There is no strong evidence of a substitution effect of exports by FDI: the effect of importer GDP on FDI sales is positive but the effect is highly insignificant statistically. We also find a negative effect of importer GDP on exports in a specification with country and pair wise fixed effects. These results are available on request.

[129] With respect to the effects of institutional quality of the importer, we once again suspect the effects of collinearity. The effect of importer per capita GDP is positive and statistically significant. We suspect that it is difficult for the model to identify the effect of institutional quality of the importer independently and that the coefficient of GDP per capita of the importer pretty much absorbs the effect of institutional quality (particularly in the regressions of FDI stocks and sales).

Table 6B.1 – Background regressions exports, FDI stocks and sales associated with FDI

	Culture, institutions and bilateral tariffs			Adding per capita GDP differences	
	Exports (1)	FDI stocks (2)	FDI sales (3)	Exports (4)	FDI stocks (5)
Log GDP exp	0.88***	1.48***	1.48***	0.88***	1.49***
	(35.06)	(31.12)	(29.68)	(34.78)	(31.25)
Log GDP imp	0.87***	0.80***	0.89***	0.88***	0.82***
	(37.06)	(18.91)	(19.83)	(38.75)	(18.66)
Log GDP cap exp	–0.94***	–1.44***	–1.43***	–0.93***	–1.39***
	(5.48)	(4.49)	(4.27)	(5.53)	(4.23)
Log GDP cap imp	–0.13	0.30*	–0.12	–0.24**	–0.09
	(1.53)	(1.77)	(0.68)	(2.46)	(0.32)
Log Distance	–0.65***	–0.58***	–0.58***	–0.65***	–0.56***
	(27.82)	(11.15)	(10.71)	(26.68)	(10.48)
Language dummy	0.30***	0.78***	0.75***	0.31***	0.81***
	(4.56)	(6.34)	(5.94)	(4.65)	(6.50)
Adjacency	0.63***	0.12	0.08	0.63***	0.12
	(8.01)	(0.72)	(0.50)	(7.99)	(0.75)
Cultural distance	0.03	–0.24***	–0.25***	0.03*	–0.24***
	(1.58)	(5.47)	(5.47)	(1.68)	(5.34)
Inst. quality exp.	0.21*	2.55***	2.55***	0.21*	2.54***
	(1.96)	(11.68)	(11.34)	(1.95)	(11.63)
Inst. quality imp.	0.56***	0.84***	1.00***	0.58***	0.94***
	(7.87)	(5.12)	(5.79)	(8.31)	(5.41)
Inst. distance	0.00	0.13*	0.12*	0.02	0.18**
	(0.03)	(1.88)	(1.65)	(0.42)	(2.42)
Log(1+Tariff)	–5.75***	–2.25	–2.06	–5.79***	–2.37
	(6.49)	(1.43)	(1.24)	(6.57)	(1.50)
Abs diff. Log GDP cap				–0.12	–0.42*
				(1.10)	(1.85)
Constant	6.22***	–11.92***	–9.51***	6.90***	–9.49***
	(5.00)	(4.35)	(3.33)	(4.47)	(3.45)
Adjusted R^2	0.79	0.65	0.62	0.79	0.65
Observations	1145	1145	1145	1145	1145

Absolute robust *t*-statistics in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. Columns 1–6: year dummies included (not shown). Column 7–9 includes importer-year and exporter-year specific dummies. Data cover the period 1984–1990.

Table 6B.1 – Continued

	Adding per capita GDP differences	Fixed effects		
	FDI sales	Exports	FDI stocks	FDI sales
	(6)	(7)	(8)	(9)
Log GDP exp	1.49***			
	(29.91)			
Log GDP imp	0.92***			
	(19.70)			
Log GDP cap exp	–1.37***			
	(3.97)			
Log GDP cap imp	–0.60**			
	(2.18)			
Log Distance	–0.56***	–0.73***	–0.72***	–0.72***
	(9.99)	(20.67)	(11.84)	(11.84)
Language dummy	0.79***	0.23***	0.60***	0.60***
	(6.16)	(4.06)	(4.82)	(4.82)
Adjacency	0.09	0.57***	0.22	0.22
	(0.54)	(8.77)	(1.52)	(1.52)
Cultural distance	–0.25***	–0.09***	–0.20***	–0.20***
	(5.32)	(4.54)	(4.78)	(4.78)
Inst. quality exp.	2.54***			
	(11.31)			
Inst. quality imp.	1.13***			
	(6.19)			
Inst. distance	0.19**	0.16***	0.05	0.05
	(2.37)	(2.84)	(0.61)	(0.61)
Log(1+Tariff)	–2.22	–7.27***	2.75	2.75
	(1.33)	(4.94)	(1.10)	(1.10)
Abs diff. Log GDP cap	–0.53**			
	(2.20)			
Constant	–6.46**	19.40***	10.67***	10.64***
	(2.26)	(38.34)	(13.33)	(13.30)
Adjusted R^2	0.62	0.87	0.83	0.83
Observations	1145	1145	1145	1145

Absolute robust *t*-statistics in parentheses. * significant at 10%, ** significant at 5%, *** significant at 1%. Columns 1–6: year dummies included (not shown). Column 7–9 includes importer-year and exporter-year specific dummies. Data cover the period 1984–1990.

Table 6B.2 – Background regressions: multilevel analysis

	Exports	FDI stocks	FDI sales
	(1)	(2)	(3)
Log GDP exporter	1.20***	1.95***	1.92***
	(12.22)	(5.41)	(5.46)
Log GDP importer	0.85***	0.60***	0.69***
	(16.45)	(3.86)	(3.82)
Log GDP cap exporter	0.83***	1.84***	1.63***
	(3.87)	(3.48)	(3.13)
Log GDP cap importer	0.83***	1.50***	1.72***
	(5.28)	(4.65)	(5.13)
Log Distance	–0.83***	–0.86***	–0.88***
	(14.75)	(8.18)	(8.26)
Language dummy	0.22	0.72***	0.71***
	(1.44)	(2.75)	(2.71)
Adjacency	0.52***	0.15	0.15
	(2.89)	(0.47)	(0.49)
Cultural distance	–0.08**	–0.23***	–0.24***
	(2.07)	(3.63)	(3.56)
Institutional quality exporter	0.64**	3.35***	3.41***
	(2.13)	(3.26)	(3.40)
Institutional quality importer	0.15	0.02	–0.13
	(0.85)	(0.06)	(0.29)
Inst. distance	0.12*	0.09	0.08
	(1.80)	(0.68)	(0.60)
Log(1+Tariff)	–5.11***	0.50	2.23
	(3.44)	(0.14)	(0.57)
Constant	–71.94***	–53.54	–43.30
	(5.35)	(1.34)	(1.02)
Observations	1145	1145	1145
log likelihood	–529	–1123	–1121

Multilevel analysis with parent, host and parent-host random effects. The coefficients relate to within-country (pair) changes. Cluster means of explanatory variables are included to ensure consistent estimators (not shown). The following cluster means are included: GDP and GDP per capita of parent by host country, GDP and GDP per capita of host by parent country, distance by host country, language and adjacency by parent and host country, and cultural distance by parent and host country.
Absolute *t* statistics in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

Part III

Conclusions and Policy Implications

7

Conclusions

7.1. Introduction

Available data show marked regularities in the world-wide pattern of FDI: developed economies are the main source of FDI and also the main recipients. It thus seems that FDI is foremost between developed, high-income countries. The aim of this study has been to explain this stylised fact. Why do some countries attract large amounts of FDI, whilst others attract only small amounts? In Chapter 1 we formulated the following overall research question as a guideline for the analysis: what are the sources of attraction for FDI? Having arrived at the end of this study, we can now assess the results.

This concluding chapter is organised as follows. Section 7.2 summarizes the main findings from this study. Section 7.3 links the conclusions from this study back to the research question. In Section 7.4 we present policy implications. Lastly, Section 7.5 suggests areas for further research.

7.2. Summary of the research results

Chapter 2 served as a first introductory analysis in the investigation into the sources of attraction for FDI. The chapter empirically investigates the stylised fact that developed countries attract the bulk of FDI whilst the least developed countries attract only a little. What factors can explain this marked pattern in world-wide FDI? The chapter investigates a number of factors that are regarded as important determinants of economic development. To what extent do these factors then explain the variation in FDI inflows across host countries? We look particularly at: human capital, inflation, institutional quality and geographic characteristics. Multinationals are generally regarded as knowledge-intensive companies. They account for about two thirds of private sector R&D and they produce, own and control most of the world's advanced technology. We therefore examine the importance of human capital for attracting FDI. Institutions are recognised as variables that affect productivity. They influence the uncertainty surrounding transactions and hence the costs associated with this. Concerning FDI, the quality of institutions affects expropriation risks, securing of intellectual property rights, the degree of corruption, the enforceability of private contracts, and the security of investment in general. The costs of operating abroad will generally be lower if the quality of institutions overseas is higher. Inflation is a measure of macro-instability. We find that institutional quality is an important determinant of total FDI inflows across host countries. Institutional quality explains up to 27 per cent of the average variation in total FDI. The effect of institutional quality is robust across different specifications. Inflation is much less robust. Human capital and geography (e.g., climate) each explain about 10 per cent of the total variation in total FDI inflows, but the effects are not robust when the effects of human capital, institutional quality or inflation, and geography are controlled for all together. Still, the single most important determinant of total FDI is GDP. GDP has a statistically significant effect in all regressions and explains over 60 per cent of the average variation in total FDI inflows across countries.

The main contribution of Chapter 2 is its additional investigation of the role of human capital in attracting FDI. In the new growth theory, human capital is considered to be important with respect to technological progress. It is a key input in the production of new knowledge and the assimilation of new technologies. We therefore investigate whether human capital is more conducive to attracting FDI in technology-intensive sectors than total FDI. We also investigate whether attracting FDI in technology-intensive sectors requires a particular type of skills, technical as opposed to, e.g., managerial skills. We look at: enrolment in science; enrolment in engineering, manufacturing and construction; and enrolment in social sciences, business and law. High-tech FDI is proxied by FDI in machinery and equipment and electrical and electronic equipment. We find that the quality of human capital appears to be relatively more important for FDI in electrical and electronic equipment than for total FDI. Our results indicate that FDI inflows in this sector are highly elastic with respect to human capital: a one per cent increase in the quality of human capital increases FDI inflows more than proportionally. Human capital is also more important than institutional quality in explaining FDI in electrical and electronic equipment. The latter is less important in FDI in electrical and electronic equipment than in total FDI. In fact, the effect of institutional quality on FDI in electrical and electronic equipment is highly insignificant when human capital is included. Human capital and institutional quality have no significant effect on FDI in machinery and equipment. This type of FDI is explained almost entirely by GDP. With regard to the type of skills, we find that is technical skills that matter particularly for attracting high-tech FDI. Technical skills (measured by enrolment in science and in engineering, manufacturing and construction) are more important for attracting FDI in machinery and equipment and electrical and electronic equipment than managerial skills. The latter (measured by enrolment in social sciences, business and law) have no significant effect on FDI in machinery and equipment nor electrical and electronic equipment, whilst having a statistically significant positive impact on total FDI inflows. The statistical significance of institutional quality on FDI in machinery and equipment and electrical and electronic equipment is very low in specifications that control for technical skills as well. So, our expectations regarding the role of human capital and skills in high-tech FDI are largely confirmed by the data. Nevertheless, our conclusions regarding the role of human capital and skills in high-tech FDI are tentative. The analysis of high-tech FDI is much inconvenienced by a limited availability of data at a sector level. More additional research is needed to corroborate the evidence on high-tech FDI in Chapter 2. This research would greatly benefit from the availability of more detailed information on FDI at a sector level (see also Section 7.5).

Chapter 2 demonstrates the factors that can potentially explain the variation in FDI inflows across host countries. Yet, the selection of explanatory variables is not tied back to a theoretical model of location selection by firms. General-equilibrium models of FDI exist for bilateral FDI. These models explain how FDI comes about and specify long-term factors that determine the magnitude of FDI between countries based on a microeconomic theory of firm decision making. The empirical analysis in Part II of this study is based on bilateral FDI.

Chapter 3 motivates and describes the research approach for our analysis in Part II. The chapter first of all presents two important theoretical models of FDI, i.e., the knowledge-capital model and the proximity-concentration trade-off hypothesis. This is followed by a critical review of the two models and the empirical work related to them. Chapter 3 argues there are three main issues in this literature that warrant further investigation. The first issue has to do with the FDI data. Important empirical contributions discussed in Chapter 3 all use FDI data that are bilateral with the U.S. only. This leaves out many observations of FDI between other countries. One of the main contributions in Part II pertains to the FDI data: we use data on bilateral FDI of the

OECD. This significantly increases the amount of observations compared to key contributions in the empirical literature on bilateral FDI that use bilateral data for the U.S. only. An issue in the data on bilateral FDI of the OECD is dependence. The data is a panel data set for multiple parent and host countries. We thus have several repeated observations: for parents over all host countries, for host countries over all parents, for parent and host countries over time, and for specific parent-host combinations. Failure to take intra-class correlations into account leads to underestimation of the standard errors of the regression coefficients and can result in spuriously significant results. Even low levels of intra-class correlation can cause the standard errors from OLS to be seriously biased downwards. The second issue that follows from our review of the literature in Chapter 3 pertains to the assumptions and empirical specification of the knowledge-capital model. The empirical specification in CMM (i) imposes linear constraints on coefficients; and (ii) includes interactions between variables. To allow for such interaction terms, CMM do not log the data, but use a linear specification instead. In this context, Chapter 3 also looks at the gravity model. The gravity equation presents an alternative model to explain bilateral FDI. The gravity model is the most commonly used model in the empirical literature to explain variation in trade or investments between countries. It is only loosely connected to theory. Compared to a standard gravity equation, the empirical specification of the knowledge-capital model is rather complex. The empirical specification of the knowledge-capital is derived from theory. Yet, to what extent do the data support the linear restrictions and the functional form of the knowledge-capital model, in particular data other than for the U.S.? The third issue in the existing literature brought forward in Chapter 3 has to do with the specification of distance in the proximity-concentration model. The chapter discusses lessons from the empirical literature on the importance of culture and institutions as intangible barriers to trade and investment. In Chapters 4, 5 and 6, we address each of the issues described above.

Chapter 4 is largely methodological in nature. This study uses multilevel techniques to account for the correlation in the data on bilateral FDI of the OECD. Chapter 4 explains the multilevel approach. We use a cross-classified multilevel technique to account for clustering of FDI within parent and host countries and parent-host combinations. The general idea of the multilevel analysis in this study is first that higher-level (here, parent, host or parent-host-combination) heterogeneity has an impact on the dependent variable. Next, that because of these higher-level effects, 'years' (annual FDI values) for the same parent country *i*, host country *j*, or the same parent-host combination tend to be more alike. The multilevel model therefore accounts for the effects of parent, host or parent-host-combination heterogeneity on FDI and subsequently explains the variance between years for parent country *i* and host *j*. Chapter 4 holds relevant lessons for empirical investigations of bilateral phenomena such as international trade, FDI, migration, etc., with panel data. The use of panel data has become increasingly prominent in the empirical literature. The use of a panel data set will generally yield more efficient estimators than cross-sectional or time series data because data vary over two dimensions, countries and time. In addition, with panel data, one can control for time invariant country-specific effects. An issue that often remains unaddressed in the literature is the clustering of observations in a panel data set: because the same units are repeatedly observed, it is no longer independent observations. In the empirical analysis of bilateral trade, FDI, migration, etc., with panel data, the issue of clustering is particularly complex since there are several repeated observations: for countries of origin (over all destination countries), for destination countries (over all origin countries), for origin and destination countries over time, and for specific origin-destination combinations. This chapter illustrates that multilevel analysis offers a useful framework to address intra-class correlation when there are several cluster variables at the same time. The advantage of the cross-classified multilevel model over cluster-robust linear regression in this study is that the former accounts for three cluster variables simultaneously. With cluster-robust linear regression one can only use one cluster variable at a time. Furthermore, this chapter shows that random effects can be a viable alternative to fixed effects in the case of many country-specific and country pair-specific effects. Contrary to common practice in the gravity literature, the cross-classified multilevel model uses random rather than fixed effects for controlling for the effects of parent, host and parent-host-combination heterogeneity. A possible drawback of random effects is the correlation between the random effects and the explanatory variables. In general, economists are of the view that, if there is a significant difference between the random effects estimator and the fixed effects estimator, the fixed effects specification and OLS estimation should be used. This chapter shows that unbiased estimates can equally be obtained with random effects, provided that the cluster means of the explanatory variables are added to the model.

Chapter 4 subsequently fits a cross-classified multilevel version of the knowledge-capital model to the FDI data of the OECD. The multilevel approach entails estimating the effect of the explanatory variables *over time* for parent i and host j. We find that, for the most part, the predictions of the knowledge-capital model as derived from theory and simulations equally apply over time. That is, coefficient sizes from the multilevel estimation are different from OLS, yet the effects of the explanatory variables on FDI over time are qualitatively similar to the country/temporal effects from OLS. What do the results from Chapter 4 tell us about possible sources of attraction for FDI? The main explanatory variables in the knowledge-capital model are GDP, relative skill endowments, trade and investment costs. Summing up, the results indicate that FDI between two countries increases in the sum of their GDPs. Convergence in income in both directions between two countries increases FDI from parent i to host j. In other words, both size and similarity between countries in terms of size are important for FDI. Third, an increase in the skilled-labour abundance of the parent will increase FDI if the parent is relatively small and/or skilled-labour scarce. On the other hand, when the parent is large and/or relatively skill abundant, an increase in *host*-country skill abundance (i.e., a decrease in the difference) will increase FDI from the parent to the host. The latter indicates that FDI from large and skill abundant OECD countries is attracted to more skill-abundant hosts. The evidence regarding the effects of GDP and relative skill endowments above is consistent with the stylised fact that FDI is foremost between developed, high-income countries. In terms of the knowledge-capital model this pattern indicates that FDI is largely of a horizontal nature. The knowledge-capital model predicts that horizontal firms dominate when markets in both countries are large and countries are similar in relative skill endowments. Economies of scale explain the need for size in both markets. The reason for skill similarity in this type of FDI is that when countries are dissimilar it becomes more profitable for firms separate production and headquarter activities and concentrate production in the skilled-labour scarce country and headquarters in the skill abundant country (vertical FDI). Concerning investment costs we find that, on the one hand, a higher level of investment costs in one host country versus another increases the level of investment in the latter (OLS-results and consistent with theoretical prediction). However, an increase in investment costs within one host country over time does not have this effect (multilevel). The results concerning the impact over time of trade costs of the host country are inconclusive. The theoretical prediction is that high trade costs in a host country induce horizontal FDI as a substitute for exports. Yet, different regressions in this chapter yield mixed results.

In Chapter 5 we test the robustness of the empirical specification of the knowledge-capital model for the OECD data. As explained in Chapter 3, the empirical specification of the model is derived from theory. Yet, are the linear constraints imposed in the empirical specification supported by the data? And how appropriate is the linear form of the model? We find that the data reject the subtractive linear restriction that parent and host-country skill abundances have equal but opposite effects on FDI, which serves to capture that differences in relative skill abundance give rise to vertical FDI. A specification in which parent and host-country skilled labour are estimated separately thus seems more appropriate. Also, a log linear model is more appropriate. However, transforming the data alters the empirical specification, which subsequently no longer represents the predictions of the knowledge-capital model. Given the empirical evidence in this chapter, we reject the knowledge-capital model as a model to explain FDI of the OECD. Subsequently, Chapter 5 estimates a gravity model of bilateral FDI. This entails that we no longer distinguish between horizontal and vertical FDI, but rather seek to explain the overall pattern of bilateral FDI of the OECD. With regard to skilled labour, we look at skilled-labour abundance as well as human capital. Next, we extend the gravity specification with GDP per capita (a proxy for the level of development) and institutional quality. The reason is as follows. High-income, developed countries are generally also the ones with high levels of human capital and/or large endowments of skilled labour. This implies that, if we do not control for the level of development, results on skilled labour may suffer from an omitted variable bias. In a similar vein, we include institutional quality based on lessons from the empirical literature on international trade that omission of institutional quality in the gravity specification biases the estimates of GDP per capita. We find positive effects on FDI from skilled labour, the level of development and institutional quality alike, despite econometric difficulties to identify the effects of each variable independently. We conclude that skilled labour, the level of development and institutional quality are all likely determinants of FDI, but that their effects coincide. We find that both parent- and host-country skilled labour, institutions and level of development affect FDI positively. These results suggest that 'proximity' between parent and host countries in terms of skilled labour endowments and/or quality, institutional quality and level of development is the key in explaining bilateral FDI: multinational firms choose locations that are 'close' to the parent country. First, our results concerning skilled labour suggest that MNEs arise in countries that are skilled-labour abundant and/or have high levels of human capital (high-quality schooling) and that this is also what makes them choose one location to host their foreign activities over another. This fits the image of multinationals as knowledge-intensive companies with often advanced production technologies. To the extent that multinationals set up new plants in a host country, the latter needs sufficient human capital to adopt the advanced technology of the multinational.[130] In addition, multinational firms choose locations that are close to the parent country in terms of the quality of governance systems. Firms' choice of a suitable location is affected by costs. The costs – adjustment costs and additional lack of trust and confidence in security of transactions – will be lower when differences in the institutional environment between the parent and the host country are small (Linders, 2006). The importance of the level of development for FDI may be explained by the importance of skilled labour and institutional quality. High-income, developed countries are generally also the ones with high levels of human capital and/or large endowments of skilled labour, as well as high-quality institutions. With reference to the empirical literature on economic growth and development (cf. Chapter 2), we assume that the causality runs from skilled labour and institutions to the level of development rather than the other way around. On the other hand, the level of development can also reflect the 'quality' of demand (income-related pattern of demand). In this case, the level of development has its own impact on FDI. In this case, proximity again matters, this time in terms of proximity of production and demand patterns.

Chapter 6 investigates the effect of different dimensions of distance on the choice between export and FDI as alternative modes of serving foreign markets. Conventional proximity-concentration theory suggests that FDI substitutes for trade if distance between countries is large, while exports become more important if scale economies in production

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[130] Multinationals may also acquire this technology from existing firms in other countries (e.g. through mergers and acquisition). In this case too, they are likely to invest predominantly in host countries with an abundance of human capital as these are the countries that generate this type of firms.

are large. The chapter extends the empirical framework for analysing the trade-off between exports and FDI. Our approach explicitly takes into account intangible barriers related to cultural and institutional differences. Unlike the mechanisms described by the proximity-concentration hypothesis, these 'intangible' barriers can affect the costs related to FDI as well as trade. We estimate gravity equations for total foreign sales (sum of exports and sales related to FDI) and the share of FDI-sales in total bilateral sales. Since the OECD data on FDI used in this study represent FDI stocks, we *derive* measures of FDI sales. We transform FDI stocks into a measure of FDI-related sales in the foreign market by using capital-output ratios. We show that different dimensions of distance affect exports and FDI differently. First, there is clear evidence in support of a conventional proximity-concentration trade-off. The share of FDI sales increases with both geographical distance and import tariffs. On the other hand, this chapter illustrates that FDI does not merely substitute for trade when transport costs and trade barriers are high. It incurs costs of its own. These costs are primarily of an intangible nature. The share of FDI in total bilateral sales decreases with language differences and cultural distance, and increases with institutional quality in both the parent and host country. Hence, 'soft' barriers are particularly important for FDI. 'Soft' barriers are particularly important for FDI because local presence entails a relatively deep involvement with and exposure to local cultures and institutions. Also, the demands in terms of language are higher for operating a plant in a foreign market compared to exporting.

7.3. Conclusions concerning the sources of attraction for FDI

What do the results of this study entail for the question as to why some countries attract so much FDI, whilst others attract so little? In other words, what are the main sources of attraction for FDI identified in this study? The relevant contributions in this respect are mainly in Chapters 2, 5 and 6. We have looked at the effects of skilled labour, level of development, institutional quality and culture. We find that both parent- and host-country skilled labour, institutions and level of development affect FDI positively. Cultural distance has a negative effect on FDI. We control for the impact of GDP in all regressions. Market size is important for FDI throughout. We conclude that proximity in terms of skilled labour, level of development, institutional quality and culture is an important source of attraction for FDI. The analysis in Chapter 2 suggests that the impact of skilled labour on FDI may differ across sectors. In particular, we find that human capital and technical skills are particularly important for attracting high-tech FDI *viz.* total FDI.

Having reached the end of this study, let's return to the questions raised at the beginning of this study. In Section 1.1, we formulated the following questions, that served as the background for this study: What is the impact of FDI on the distribution of economic activity across space? Does FDI lead to more clustering of economic activity in important centres, thus increasing gaps between countries? Or, does it promote a more even spread of economic activities globally? In view of our results, we speculate that, overall, the effect of FDI will be more towards the first. That is, FDI will lead to more clustering of economic activity in important centres. This study has shown that mass, that is, market size as well as absorption capacity, and proximity are the key drivers of FDI. Absorption capacity can be defined in terms of skilled labour, institutional quality and/or level of development in general. Proximity may be in terms of institutions, culture, or income-related patterns of production and demand. These factors provide explanations for the stylised fact that FDI is foremost between developed, high-income countries. Based on this study, we tend to say that FDI follows patterns of economic geography that are already there, rather than changing patterns or shaping a new geography of its own. This also implies that the potential of FDI as medium to foster catching up by developing countries is limited (see below).

7.4. Policy implications

In the economic literature, FDI is generally considered to have a positive impact on the welfare of host countries.[131] FDI can have a direct impact on the welfare in the host country by raising the rate of investment.[132] FDI can also indirectly affect the welfare of the host country by raising productivity levels of domestic firms. Assuming that knowledge is, at least partly, a public good, it may spill-over to and increase the productivity of domestic firms in the host countries.[133] For most countries, foreign sources of technology are of dominant importance for productivity growth (Keller, 2004).

[131] In sociology on the other hand, the dominant view is that a high degree of foreign capital penetration in developing countries has a detrimental effect on their growth in the long run, arising from the repatriation of profits and negative externalities such e.g., over-urbanisation, adoption of inappropriate technology and disregard for the local environment (see, e.g., Bornschier and Chase Dunn, 1985, and Dixon and Boswell, 1996).

[132] Roy and Van den Berg (2006) estimate for the U.S. that a 10 percentage point increase in the share of FDI in GDP raises economic growth by 0.17 per cent over a period of 30 years (1970–2001). However, evidence by Borensztein et al. (1998) suggests that the effect of FDI on economic growth may depend on the level of education in the host country. Borensztein et al. examine the relationship between FDI from industrialised countries and economic growth in 69 developing countries. They find that FDI contributes relatively more to economic growth than domestic investments. They attribute this to better management techniques and more advanced technology. However, the higher productivity of FDI only holds when the host has a minimum threshold of human capital. Borensztein et al. conclude that FDI only contributes to economic growth when there is sufficient capacity in the host country to absorb advanced technologies.

[133] The notion of FDI as a channel for technology diffusion and economic development has roots in the convergence literature. In the convergence literature, growth rates in less advanced countries are, in part, explained by a catch-up process in the level of technology. In a typical model of technology diffusion, backward countries achieve substantial technological progress and reduce the technology gap with more advanced countries by assimilating superior productive techniques developed in the leader countries and by modernising obsolete plants and equipment accordingly. As a result, they will gradually catch up with technological leaders. Research on technology diffusion includes Nelson and Phelps (1966), Grossman and Helpman (1991, Ch. 11 and 12) and Barro and Sala-i-Martin (1995, Ch. 8) and Smeets (2009).

Direct or indirect interaction with companies from technologically advanced countries is then critical for countries to get access to more advanced knowledge.[134]

This study underlines the importance of investing in skilled labour and high-quality institutions to attract FDI and thus to increase the potential to benefit from FDI. Education and institutional systems are man-made and hence can be made subject of policy. Yet, the results from our study also imply that the benefits of FDI are likely to be limited to developed countries. It is these countries that have the 'proper' education and institutional systems in place that attract FDI. Furthermore, their level of development entails a pattern of demand that suits the activities of MNEs. Countries that could potentially benefit most from FDI and the knowledge embedded in it, i.e. the least developed countries (e.g. UNCTAD, 1996 and 2004), may not be able to do so because they fail to attract FDI in the first place. Investments in education and institutions are costly and improvements materialise only over long periods of time. Besides, institutional change in these countries may be further constrained by cultural factors and geographic circumstances. If cultural and geographic factors shape the incentives for institutional change, policy intervention is even harder and more costly, because cultural and geographic constraints are hard to overcome (Linders, 2006). Hence, this study illustrates that the effectiveness of FDI as a channel for economic development in the least developed countries has its limitations. In the convergence literature, growth rates in less advanced countries are, in part, explained by a catch-up process in the level of technology. In a typical model of technology diffusion, backward countries achieve substantial technological progress and reduce the technology gap with leading countries by assimilating superior productive techniques developed in the leader countries and by modernising obsolete plants and equipment accordingly. As a result, they will gradually catch up with technological leaders. However, Abramovitz (1986 and 1994) points out that limitations to laggards' so-called social capabilities and technological congruence may restrict catching up: "Countries' potential for rapid growth by catch-up (...) is not determined solely by the gaps in the levels of technology, capital intensity and efficient allocation that separate them from leading countries. They are restricted also by natural resource endowments and more generally because of the size of their markets, relative factor supplies and income-constrained patterns of demand that make their technical capabilities and their product structures incongruent with those that characterise countries that operate at or near the technological frontiers. And they are limited, finally, by those

[134] The results concerning spill-over effects from firm-level studies are mixed (see Görg and Strobl, 2001, and Keller, 2004, for surveys), although a number of recent microeconometric studies by Haskel et al. (2002), Griffith et al. (2003), Keller and Yeaple (2003) and Javorcik (2004) suggest that there can indeed be positive, and in some cases large spill-over effects from FDI. The studies involve the U.K., the U.S. and Lithuania. Xu (2000) finds that technology transfer by American MNEs contributes to productivity growth in developed countries, but not in developing countries. Similar to Borensztein et al. (1998), Xu finds that a country needs to reach a minimum human capital threshold level to benefit from the technology transfer. Most least developed countries do not meet this threshold requirement.

institutional characteristics that restrict their abilities to finance, organise and operate the kinds of enterprises that the technologies of the frontiers require" (Abramovitz, 1994, p. 25-26). This study explains (part of the reason) why these factors limit the catch up potential of least developed countries: because the lack of skilled labour, an income-constrained pattern of demand and low institutional quality inhibit a potential carrier of the superior productive techniques developed in the leader countries that are needed in the process of catch up, i.e. FDI.

This study illustrates the importance of skilled labour for FDI. This evidence is usually taken to indicate that FDI is of a predominantly horizontal character. However, skilled labour may be important for vertical FDI as well (cf. Yeaple, 2003). In a recent report on globalization, the IMF (2007b) reports that "the composition of inward FDI in both advanced and developing countries has been more concentrated in high-skill sectors, including high/medium-high-technology manufacturing and the knowledge-intensive service sector." This pattern is consistent with evidence presented in different parts of this study, i.e. that MNEs account for half of global R&D and two thirds of private sector R&D (Chapter 1) and that MNEs produce, own and control most of the world's advanced technology (Chapter 2). This implies that occurring vertical FDI will also take place in high-skill sectors. MNEs look for cheap labour, but this does mean they look for low-skilled labour. It follows that preserving the skill base (by training and education) is important not only for the development of MNEs in a home country, but also for keeping skill-intensive production in the home country. This may become increasingly imminent in the future. True, according to the IMF (2007a), the intensity of offshoring of the production of intermediates is still small in the overall economy and offshoring is likely to involve the least skill-intensive stages of production in these skilled sectors.[135] However, with a growing pool of skilled workers in developing countries, especially Asia (IMF, 2007a), and MNEs being able to move parts of their production (quickly) in and out of countries, one cannot be complacent.[136]

Finally, in the context of the knowledge-capital model the explanation why the overwhelming share of world investment is between high-income, developed economies is that FDI is of a predominantly horizontal nature. In this scenario the labour-market effects in the parent country tend to be relatively limited, since by definition horizontal FDI involves setting up plants in various markets in addition to the parent country. However, using the knowledge-capital model as a guideline one may underestimate the labour-market effects of FDI in the parent country. As argued in this study the knowledge-capital model's distinction between horizontal and vertical FDI on the basis of skill similarities/differences may well be somewhat theoretical and part of FDI between similar countries may actually be vertical. This study has used a gravity model

[135] However, the available data do not allow confirmation of this (IMF, 2007a).
[136] In this sense, Friedman's call for concern is not all together beside the point.

to examine the impact of skilled labour. The gravity model does not distinguish between horizontal and vertical motivations for FDI. In order to evaluate employment effects we need to go beyond the general model and look 'inside the data', i.e. at the level of firm strategy. Case study research may provide more exact results.

7.5. Suggestions for further research

A first area for further research is FDI at the sector level. This study has largely examined the overall pattern of FDI. There are some strong regularities in the overall pattern of FDI as suggested by the stylized facts presented in this study. Yet, looking at the overall pattern pays little attention to the diversity that lies beneath. We looked at FDI at a sector level in Chapter 2, but the analysis was much inconvenienced by a limited availability of data. The study of the diversity in FDI would be greatly facilitated by the availability of more detailed information on FDI at a sector level.

A second area for further research relates to theoretical models of FDI. In Chapter 5 we examined the knowledge-capital model of bilateral FDI. The knowledge-capital model provides the most articulate general equilibrium model of MNE with proper microeconomic foundations. Still, we relinquished the knowledge-capital model on empirical grounds and continued our empirical analysis with a gravity model of bilateral FDI. However, contrary to international trade the theoretical foundations for the gravity equation have not yet been established fully satisfactorily for FDI. Hence, the search for a theoretical model of FDI that withstands a confrontation with the data is an area that deserves further attention.

A third area for further research relates to the effects of vertical FDI on the demand for skills in the parent country. Few studies on FDI estimate the effect of overseas production on the demand for skilled labour in the parent country for the U.S., Sweden and Japan (Slaughter, 2000, Hansson, 2001, Head and Ries, 2002, respectively). The results critically depend on whether the analysis is carried out using industry- or firm-level data (Barba Navaretti and Venables, 2006, Ch. 9): the results support the idea that vertical FDI has a positive effect on the skill intensity of MNEs' activities in the home country (*firm*-level); they fail to explain average skill upgrading in manufacturing sectors (*industry*-level).[137] Furthermore, this research is generally based on the idea that MNEs transfer low-skilled jobs. However, the present study has argued that the activities of multinational firms involve skilled labour and human capital. This can even extend to vertical FDI. The research needed in this direction includes a detailed investigation into the type and skill content of activities that are being relocated. For instance, the IMF (2007a) surmises that offshoring in skilled sectors is likely to involve only the least skill-

[137] A recent study by the IMF (2007b) suggests that technological progress is by far the most important determinant of the increased demand for skilled labour.

intensive stages of production, but also notes that the available data do not allow confirmation of this. More work in terms of data, number of countries and concepts is needed in this area if we want to make useful assessment of the effects of vertical FDI on the skill content of parent countries.

Finally, this study has empirically examined the effect of multiple dimensions of distance on (the choice between) exports and FDI. We (implicitly) assumed that the effects of distance are constant over time. We have focused on the cross-sectional effects and also regarding estimations over time (fixed effects estimation and multilevel analysis) we assumed that the effects are constant over time. In other words, the sample period does not matter. A subject for further investigation is the (in)variability of the effects of distance over time. Do the effects of distance on trade and FDI vary across different periods of time? Despite falling costs of transport and communication, the effect of geographic distance on trade is found to be very persistent over time (e.g., Frankel, 1997, Disdier and Head, 2008, Linders, 2006). Yet, from the perspective of this study, there may be changes *within* the overall effect. And what about the effect over time of distance – as a whole and the multiple dimensions – on FDI? To our knowledge, little has been done in this area.

Data Appendix

This appendix provides details of data definitions and sources used in this study. Descriptive statistics are given in the respective chapters.

FDI and trade

FDI inflows

Total FDI_i	The simple average of annual FDI inflows in current US$ over the period 1995–2004. Data were taken from the *International Financial Statistics* (IFS) Online of the International Monetary Fund.
High-tech FDI	FDI inflows in ISIC Rev.3 sector 29 (machinery and equipment) and sector 30,31,32 (electrical and electronic equipment). The indicators are the simple average of annual FDI inflows in the period 1995–2004. Data are from the UNCTAD FDI/TNC database.

Bilateral FDI

$FDI_{t(ij)}$	Outward FDI stock in millions of real U.S. dollars. Panel 1982–1992. Source: OECD International Direct Investment Statistics.
FDI sales	(Value of FDI stock) * *GDP/K*, where *GDP* and *K* denote real GDP and capital stock, respectively constructed from the Penn World Tables 5.6. In Chapter 6 we used the capital-output ratio of destination countries to transform FDI stocks into sales related to FDI, the idea being that output from FDI is determined foremost by the characteristics of the local market. Still, one may also argue that it is the technology and/or management techniques of the parent firm (origin country) that determine output. In this case one would apply the capital-output ratio of the country of origin. Both methods yield similar estimations results.
Bilateral trade	Exports from country *i* to *j*. Source: UN COMTRADE database for bilateral trade.

Economic indicators

Chapter 2	GDP in current US$. The simple average over the period 1995–2004. Source: World Development Indicators.
Chapters 4-6	Real GDP constructed from GDP per capita and population data. Data on GDP per capita and population are from the Penn World Tables 5.6.
Inflation	The average annual growth (in percentage) of the GDP deflator in the period 1995–2004. Source: World Development Indicators Online 2006.

Human capital and skills

Amount of schooling	Average education attainment level in number of years. Source: Barro and Lee (1993) data.
Quality of schooling	Students' performance in mathematics and science from Hanushek and Kim (1995). The measure combines all the information on international mathematics and science tests available for countries from 1965 through 1991. Performance series are observed for 39 countries, but Hanushek and Kim extend these quality measures to other countries by imputing missing values from international test score regressions.
Skilled-labour abundance	The sum of ISCO-68 categories 0/1 (professional, technical and kindred workers) and 2 (administrative workers) in employment divided by total employment. Source: Yearbook of Labour Statistics published by the International Labour Organisation.
Type of skills	Enrolment in science; enrolment in engineering, manufacturing and construction; and enrolment in social sciences, business and law. The variables are the average percentage of (totally enrolled) students in tertiary education (ISCED levels 5–6) in science, engineering, manufacturing and construction, and

	social sciences, business and law, respectively, in the period 1998–2004. Source: UNESCO Global Education Digest 2005 CD-Rom.

Geographic variables

Island	Dummy variable indicating whether countries are islands. Source: CIA factbook (www.cia.gov/cia/publications/factbook).
Climate	The percentage of population living in temperate ecozones. Source: Mellinger et al. (2000).

Traditional distance measures

Distance	Distance between capital cities (in miles). Source: CEPII.
Language	Dummy indicating whether two countries share a common official language. Source: CEPII.
Colony	Dummy indicating whether two countries share a colonial past. Source: CEPII.
Adjacency	Dummy indicating whether or not countries share a common border. Source: CEPII.
Tariffs	Trade-weighted applied tariffs. Tariffs are for 1999. Source: WITS.

Trade and investment costs

Trade costs CMM	Index ranging from 0–100 of impediments to trade. Simple average of a number of indexes reported in the World Competitiveness Report. 1986, 1989–1994
Trade costs BDH	Trade openness measure from Penn World Tables, defined as (imports+exports)/GDP. Trade costs are defined as 100 minus the trade openness measure.

Investment costs CMM	Index ranging from 0–100 of investment impediments in the host country. Simple average of a number of indexes reported in the World Competitiveness Report. 1986, 1989–1994. Indexes include: - Restrictions on ability to acquire control in domestic company - Limitations on ability to employ foreign skilled labour - Restraints on negotiating joint ventures - Strict controls on hiring and firing practices - Market dominance by a small number of enterprises - Absence of fair administration of justice - Difficulties in acquiring local bank credit - Restrictions on access to local and foreign capital markets - Inadequate protection of intellectual property
Investment costs BDH	FDI openness measure for host country recently obtained from Business Environment Risk Intelligence, S.A. (BERI). Includes measures of political risk, financial risk, and other economic indicators. Investment barriers are defined as 100 minus the BERI's composite score.

Cultural and institutional variables

Cultural distance	Kogut-Singh index[138] of four dimensions of national culture identified by Hofstede (1980; 2001). These variables are: masculinity/femininity; uncertainty avoidance; individualism/ collectivism; and power distance. Each is constructed on the basis of a principal components analysis, and intends to reflect

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[138] In formula form the Kogut-Singh index is defined as: $D_{i,j} = \frac{1}{K}\sum_{k=1}^{K}\frac{\left(I_{i,k} - I_{j,k}\right)^2}{V_k}$, where $D_{i,j}$ is the measure of distance between country i and country j, K the number of observed indicators. $I_{i,k}$ ($I_{j,k}$)indicates the score on indicator k for country i (country j), and V_k indicates the variance of this dimension k across all countries in the sample.

	the stance of a distinct set of work-related norms and values in national cultures.
Institutional quality	A simple average of six governance indicators of perceived institutional quality from Kaufmann (2005). The six indicators have been determined on the basis of principal components analysis. The indicators are: voice and accountability; political stability; government effectiveness; regulatory quality; rule of law; control of corruption. Data are for 1996.
Institutional distance	Kogut-Singh index of the six governance indicators from Kaufmann (2005).

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Nederlandse samenvatting

Inleiding

Multinationals spelen een belangrijke rol in een globaliserende wereld. Zij belichamen bij uitstek de toenemende mobiliteit van bedrijven en productiefactoren. De activiteiten van multinationals, die we kunnen meten in de vorm van hun directe buitenlandse investeringen (hierna aangeduid als FDI) zijn sterk toegenomen in de laatste twee decennia. De toename van FDI-voorraden en -stromen was groter dan de groei van het wereldwijde bruto nationale product, van kapitaalvoorraden en van de internationale handel. Dit roept een aantal vragen op, die de achtergrond vormen voor deze studie. Welk effect heeft FDI op de wereldwijde verdeling van economische activiteit? Empirisch bewijs laat een sterke clustering van economische activiteit in een beperkt aantal belangrijke economische centra zien. Welke rol speelt FDI hierin? Leidt FDI tot een verdere samenklontering van economische activiteit in de bestaande centra en daarmee tot toenemende verschillen tussen landen? Of bevordert het een meer gelijkmatigere spreiding van economische activiteiten over de wereld? Deze vragen zijn interessant (voor de economische onderzoeker) en belangrijk (vanuit maatschappelijk perspectief).

Om deze vragen te kunnen beantwoorden moeten we begrijpen welke onderliggende factoren FDI bepalen. Dat is het doel van deze studie. De overkoepelende onderzoeksvraag luidt: welke factoren vormen een bron van aantrekkingskracht voor FDI? Het uitgangspunt voor deze studie vormen enkele zogenaamde *stylised facts*: statistieken laten zien dat het patroon van FDI regelmatig is. FDI speelt zich vooral af tussen rijke, ontwikkelde landen. De minst ontwikkelde landen trekken zelfs minder FDI aan dan men op grond van hun aandeel in het wereldwijde inkomen zou verwachten. Het doel van deze studie is om dit opmerkelijke patroon van wereldwijde FDI te verklaren. Waarom trekken sommige landen veel FDI aan, terwijl andere slechts kleine hoeveelheden aantrekken?

Samenvatting van de onderzoeksresultaten

Hoofdstuk 2 onderzoekt het *stylised fact* dat ontwikkelde landen het overgrote deel van FDI aantrekken terwijl maar een fractie naar de minst ontwikkelde landen vloeit. Hoe valt dit opmerkelijke patroon in wereldwijde FDI te verklaren? Het hoofdstuk onderzoekt enkele factoren die in de economische groeiliteratuur bekend staan als belangrijke motoren van economische ontwikkeling. De vraag in Hoofdstuk 2 is vervolgens: kunnen deze factoren ook de variatie in de instroom van totale FDI over bestemmingslanden verklaren? We kijken in het bijzonder naar: *human capital*, inflatie, institutionele kwaliteit en geografische kenmerken. Multinationals worden doorgaans beschouwd als kennisintensieve bedrijven. Ze nemen tweederde van de totale uitgaven aan private R&D voor hun rekening en ze produceren, bezitten of controleren het grootste gedeelte van alle *high tech*. We onderzoeken daarom de rol van *human capital* in het aantrekken van FDI. Instituties worden gezien als een factor die de productiviteit in een land beïnvloedt. Ze beïnvloeden de risico's rondom transacties en daarmee de transactiekosten. Wat betreft FDI is de kwaliteit van instituties onder andere van invloed op het risico van onteigening, de bescherming van intellectueel eigendom, de mate van corruptie, de uitvoerbaarheid van private contracten en de zekerheid van investeren in het algemeen. De kosten van het opereren in een buitenlandse markt zullen over het algemeen lager zijn naarmate de kwaliteit van instituties daar hoger is. Inflatie is een maatstaf voor de macro-economische instabiliteit van een bestemmingsland. We vinden dat institutionele kwaliteit een belangrijke determinant is van de instroom van FDI in bestemmingslanden. Institutionele kwaliteit verklaart tot 27 procent van de gemiddelde variatie in inwaartse FDI. Het effect van institutionele kwaliteit is bovendien robuust. Inflatie is veel minder robuust. Menselijk kapitaal en geografische kenmerken (onder andere klimaat) verklaren ieder ongeveer 10 procent van de variatie in inwaartse FDI over bestemmingslanden, maar de effecten zijn niet robuust wanneer we gelijktijdig controleren voor de effecten van menselijk kapitaal, inflatie of institutionele kwaliteit en geografische kenmerken. Veruit de belangrijkste determinant van de instroom van FDI in bestemmingslanden is evenwel het bruto nationaal product (BNP). BNP heeft een statistisch significant effect in alle regressies en verklaart meer dan 60 procent van de gemiddelde variatie in de instroom van FDI over bestemmingslanden. Dit suggereert dat marktomvang een belangrijke bron van aantrekkingskracht is voor FDI.

De voornaamste bijdrage van Hoofdstuk 2 aan de bestaande literatuur is de aanvullende analyse van de rol van *human capital* in het aantrekken van FDI. In de zogenaamde 'nieuwe groeitheorie' is *human capital* belangrijk met het oog op technologische vooruitgang. *Human capital* speelt een sleutelrol in de ontwikkeling van nieuwe kennis en de assimilatie van nieuwe technologieën. We onderzoeken daarom of *human capital* meer bevorderlijk is voor het aantrekken van FDI in technologie-intensieve sectoren dan voor de instroom van FDI in zijn geheel. Daarnaast bekijken we of het aantrekken van FDI in technologie-intensieve sectoren een bepaald soort expertise vergt, namelijk technische in plaats van bijvoorbeeld managementvaardigheden. We kijken naar: het percentage studenten in de exacte wetenschappen; het percentage studenten in de technische wetenschappen; en het percentage studenten in de sociale wetenschappen, bedrijfswetenschappen en rechten. *High-tech* FDI is gedefinieerd als FDI in de sectoren ‘machines en apparaten’ en ‘elektrische en elektronische apparatuur’. De kwaliteit van *human capital* blijkt relatief belangrijker voor FDI in elektrische en elektronische apparatuur dan voor totale FDI. Onze resultaten duiden er op dat de instroom van FDI in deze sector zeer elastisch is met betrekking tot *human capital*: een toename in de kwaliteit van *human capital* van 1 procent verhoogt de instroom van FDI meer dan evenredig. *Human capital* is tevens belangrijker dan institutionele kwaliteit voor het verklaren van FDI in elektrische en elektronische apparatuur. Laatstgenoemde factor is minder belangrijk voor de instroom van FDI in elektrische en elektronische apparatuur dan voor totale inwaartse FDI. Sterker nog, wanneer we *human capital* opnemen in de regressievergelijking is het effect van institutionele kwaliteit op FDI in elektrische en elektronische apparatuur zeer insignificant. *Human capital* en institutionele kwaliteit hebben geen statistisch significant effect op FDI in machines en apparaten. Dit type FDI wordt vrijwel geheel verklaard door BNP. Wat betreft het type vaardigheden dat van belang is voor het aantrekken van high-tech FDI vinden we dat vooral technische vaardigheden ertoe doen. Technische vaardigheden (gemeten als het percentage studenten in de exacte wetenschappen en in de technische wetenschappen) zijn belangrijker voor het aantrekken van FDI in de sectoren machines en apparaten en elektrische en elektronische apparatuur dan management vaardigheden. De laatste (gemeten als het percentage studenten in de sociale wetenschappen, bedrijfswetenschappen en rechten) hebben geen significant effect op FDI in machines en apparaten en elektrische en elektronische apparatuur, terwijl ze een positief en statistisch significant effect hebben op de totale instroom van FDI. Institutionele kwaliteit is zeer insignificant wanneer we gelijktijdig controleren voor technische vaardigheden. We concluderen dat onze verwachtingen aangaande de rol van *human capital* en vaardigheden in *high-tech* FDI grotendeels bevestigd worden. Maar de resultaten zijn voorlopig. De analyse van *high-tech* FDI wordt bemoeilijkt door een beperkte beschikbaarheid van gegevens op sectorniveau. Meer vervolgonderzoek is nodig om het bewijs inzake *high-tech* FDI in Hoofdstuk 2 te bevestigen (zie ook hieronder). Dit onderzoek zou veel profijt hebben van een grotere beschikbaarheid van uitgebreide informatie over FDI op het niveau van industriële sectoren.

Hoofdstuk 2 vormt een eerste inleidende empirische analyse naar de mogelijke bronnen van aantrekkingskracht voor FDI. De keuze van de verklarende variabelen is echter niet theoretisch onderbouwd. Algemeen evenwichtsmodellen bestaan wel voor bilaterale FDI. Deze modellen verklaren hoe FDI tot stand komt, en tonen aan welke lange-termijnfactoren de omvang van FDI van land *i* naar land *j*, op basis van een micro-economische theorie van de besluitvorming door bedrijven. De empirische analyse in Deel II van deze studie is gebaseerd op bilaterale FDI.

Hoofdstuk 3 motiveert en beschrijft de onderzoeksopzet in Deel II. Het hoofdstuk introduceert allereerst de twee belangrijkste theoretische modellen van FDI, het zogenaamde *knowledge-capital model* en de *proximity-concentration trade-off* hypothese. Het *knowledge-capital model* is het meest elegante algemeen evenwichtsmodel van FDI met micro-economische onderbouwing. Het model integreert twee motieven voor FDI: het omzeilen van (hoge) handelsbarrières bij het bedienen van een buitenlandse markt (horizontale FDI) en het uitbaten van verschillen in de kosten van productiefactoren als gevolg van verschillende relatieve factorhoeveelheden tussen landen door productie naar het buitenland te verplaatsen (verticale FDI). De *proximity-concentration trade-off* hypothese is een model van horizontale FDI. Om een buitenlandse markt te bedienen hebben bedrijven de keuze tussen export en lokale productie in de buitenlandse markt via horizontale FDI. De *proximity-concentration trade-off* hypothese modelleert deze keuze als een afruil tussen de nabijheid van lokale markten (en daarmee het reduceren van transportkosten) en het concentreren van productie op één plaats teneinde schaalvoordelen te kunnen benutten. Het model voorspelt dat FDI toeneemt naarmate de afstand tussen twee landen groter wordt, terwijl andersom export belangrijker wordt wanneer schaalvoordelen in productie toenemen. De beschrijving van de twee theoretische modellen wordt gevolgd door een kritische beschouwing daarvan en het daaraan gerelateerde empirische werk. Hoofdstuk 3 stelt dat er drie belangrijke *issues* zijn in deze literatuur die aanleiding geven tot nader onderzoek. Het eerste heeft te maken met de FDI-data. Belangrijke empirische bijdragen tot nog toe maken uitsluitend gebruik van gegevens over bilaterale FDI van en naar de VS. Dit laat veel observaties van FDI tussen andere landen buiten beschouwing. Één van de bijdragen van deze studie heeft betrekking op de data: in Deel II van deze studie gebruiken we gegevens over bilaterale FDI van de Organisatie voor Economische Samenwerking en Ontwikkeling (OESO). De data hebben betrekking op FDI tussen OESO-landen onderling en van OESO-landen naar niet-OESO-landen. Dit levert een substantiële verhoging op van het aantal waarnemingen in vergelijking met belangrijke bijdragen in de literatuur over bilaterale FDI, die gegevens over bilaterale FDI voor alleen de VS gebruiken. Een *issue* in de data is afhankelijkheid. De FDI-data vormen een panel-dataset met meerdere oorsprong- en bestemmingslanden. Daarbij is sprake van diverse herhaalde observaties: voor oorspronglanden over alle bestemmingslanden, voor bestemmingslanden over alle oorspronglanden, voor oorsprong- en bestemmingslanden over de tijd en voor bepaalde combinaties van oorsprong/bestemming. Het niet rekening houden met *intraclass correlation* leidt tot een onderschatting van de standaardfouten van de regressiecoëfficiënten en kan leiden tot schijnbaar significante resultaten. Zelfs lage niveaus van *intraclass correlation* kunnen ertoe leiden dat standaardfouten met OLS lager worden ingeschat dan ze werkelijk zijn. Een tweede kwestie heeft betrekking op de empirische specificatie van het *knowledge-capital model*. De empirische specificatie van het *knowledge-capital model* legt een bepaalde structuur op aan de data: er worden (i) lineaire restricties opgelegd aan coëfficiënten; en er worden (ii) interacties van variabelen opgenomen. Om deze interactietermen mogelijk te maken worden er geen logaritmes van de data genomen maar wordt in plaats daarvan een lineaire specificatie gebruikt. Hoofdstuk 3 kijkt in dit verband ook naar het graviteitsmodel. De graviteitsvergelijking behelst een alternatief model voor het verklaren van bilaterale FDI. Het graviteitsmodel is het meest gebruikte model in de empirische literatuur om variatie in handel of investeringen tussen landen te verklaren. Het is slechts losjes verbonden met de theorie. Vergeleken bij een standaard graviteitsvergelijking is de empirische specificatie van het *knowledge-capital model* nogal complex. De empirische specificatie van het *knowledge-capital model* wordt afgeleid van de theorie, maar de vraag is in hoeverre de data het opleggen van de lineaire restricties en de functionele vorm van het *knowledge-capital model* toelaten – met name andere data dan die voor alleen de VS. De derde kwestie in de bestaande literatuur die in Hoofdstuk 3 naar voren wordt gebracht heeft te maken met de specificatie van afstand in de *proximity-concentration trade-off* hypothese. Het hoofdstuk bespreekt de lessen uit de empirische literatuur over het belang van cultuur en instituties als zogenaamde immateriële barrières voor internationale handel en investeringen. In Hoofdstukken 4, 5 en 6 pakken we elk van de hierboven beschreven punten op.

De bijdrage van Hoofdstuk 4 is grotendeels methodologisch. Deze studie gebruikt multilevel technieken om rekening te houden met de correlatie in de FDI-data van de OESO. Hoofdstuk 4 legt de *multilevel* benadering uit. We gebruiken een zogenaamd *cross-classified multilevel model* om rekening te houden met clustering van FDI-observaties binnen oorsprong- en bestemmingslanden en combinaties van oorsprong/bestemming. Het algemene idee van de *multilevel* analyse in deze studie is ten eerste dat heterogeniteit van een hogere orde (hier oorsprong, bestemming en combinaties oorsprong/bestemming) een effect heeft op de afhankelijke variabele FDI. En vervolgens dat, vanwege deze hogere-orde effecten, 'jaren' (jaarlijkse waarden van FDI) voor dezelfde oorsprong *i*, bestemming *j* of dezelfde combinatie van oorsprong/bestemming meer op elkaar lijken. Het *multilevel* model controleert daarom voor de effecten van heterogeniteit tussen landen en -combinaties op FDI en verklaart vervolgens de variantie tussen jaren voor oorsprong *i* en bestemming *j*. Hoofdstuk 4 bevat relevante lessen voor empirisch onderzoek naar bilaterale verschijnselen zoals internationale handel, FDI, migratie, et cetera, met panel-data. Panel-data zijn steeds prominenter geworden in de empirische literatuur. Het gebruik van een panel-dataset leidt over het algemeen tot efficiëntere schatters dan cross-sectie data of tijdreeksdata omdat de gegevens over twee dimensies variëren, namelijk landen en tijd. Met panel-data kan men tevens controleren voor landspecifieke effecten. Een onderwerp dat vaak onbesproken blijft in de literatuur is de mogelijke clustering van observaties in een panel-dataset: omdat telkens dezelfde eenheden worden geobserveerd zijn observaties niet langer onafhankelijk. In de empirische analyse van bilaterale handel, FDI, migratie, et cetera, met panel-data is de kwestie van clustering bijzonder complex aangezien er diverse herhaalde observaties over de tijd zijn: voor oorspronglanden (over alle bestemmingslanden), voor bestemmingslanden (over alle oorspronglanden), voor oorsprong- en bestemmingslanden over de tijd en voor bepaalde combinaties van oorsprong/bestemming. Dit hoofdstuk laat zien dat *multilevel* analyse een geschikt raamwerk biedt om met intraclass correlation om te gaan wanneer er meerdere clustervariabelen tegelijkertijd zijn. Het voordeel van het *cross-classified multilevel model* ten opzichte van lineaire regressie met clusterrobuuste standaardfouten in deze studie is dat de eerste methode met drie clustervariabelen tegelijk rekening houdt. Bij lineaire regressie met clusterrobuuste standaardfouten kan men slechts één clustervariabele tegelijkertijd gebruiken. Bovendien toont het hoofdstuk aan dat *random effects* een goed alternatief kunnen vormen voor *fixed effects* in het geval van talrijke land- en paarspecifieke effecten. Anders dan te doen gebruikelijk in bijvoorbeeld de graviteitsliteratuur gebruikt het *multilevel* model *random* in plaats van *fixed effects* om te controleren voor effecten van heterogeniteit tussen oorsprong- en bestemmingslanden en combinaties van oorsprong/bestemming. Een potentieel nadeel van *random effects* is de correlatie tussen de *random effects* en de verklarende variabelen. Economen verkiezen daarom vaak *fixed effects*. Dit hoofdstuk laat echter zien dat consistente schatters ook kunnen worden verkregen met *random effects*, mits de clustergemiddelden van de verklarende variabelen aan het model worden toegevoegd.

Hoofdstuk 4 schat vervolgens een *cross-classified multilevel* versie van het *knowledge-capital model* met de gegevens over bilaterale FDI van de OESO. De *multilevel* benadering houdt in dat het effect van de verklarende variabelen voor oorsprong i en bestemming j over de tijd wordt geschat. We vinden grotendeels dat de voorspellingen van het *knowledge-capital model* zoals afgeleid van de theorie ook in de tijd van toepassing zijn. Dat wil zeggen, de omvang van de coëfficiënten in de *multilevel* schatting verschilt weliswaar van de OLS-resultaten, maar de effecten van de verklarende variabelen op FDI in de tijd zijn kwalitatief gelijk aan de effecten over landen en tijd van OLS. Wat kunnen we uit Hoofdstuk 4 afleiden over mogelijke bronnen van aantrekkingskracht voor FDI? De belangrijkste factoren in het model zijn BNP, hoeveelheid hooggeschoolde arbeid, handel- en investeringskosten. FDI tussen twee landen neemt allereerst toe met de som van hun beider BNP. Bovendien neemt FDI van i naar j toe met inkomensconvergentie tussen twee landen in beide richtingen. Met andere woorden, zowel omvang als gelijkheid in grootte tussen twee landen is belangrijk voor FDI. Ten derde, een toename in de relatieve hoeveelheid hooggeschoolde arbeid in i zal FDI naar j doen toenemen wanneer i relatief klein is en over relatief minder hooggeschoolde arbeid beschikt dan bestemming j. Indien i daarentegen groot is en relatief meer hooggeschoolde arbeid heeft dan j, zal het juist een toename in de relatieve hoeveelheid hooggeschoolde arbeid van j (dus een afname van het verschil) zijn die FDI van i naar j doet toenemen. Dit laatste impliceert dat FDI vanuit grote landen die tevens een hoog aandeel hooggeschoolde arbeid hebben, wordt aangetrokken naar landen met relatief meer hooggeschoolde arbeid. De resultaten voor BNP en hoeveelheid geschoolde arbeid zijn consistent met het *stylised fact* dat het overgrote deel van wereldwijde FDI zich afspeelt tussen rijke, ontwikkelde economieën. Volgens het *knowledge-capital model* betekent dit patroon dat wereldwijde FDI grotendeels horizontaal is. Het model voorspelt namelijk dat horizontale FDI overheerst wanneer landen vergelijkbaar zijn in termen van (economische) grootte en relatieve hoeveelheden hooggeschoolde arbeid. Horizontale multinationals hebben productiefaciliteiten in zowel de thuismarkt i als de buitenlandse markt j. Schaalvoordelen in productie verklaren waarom grootte van beide markten belangrijk is. Gelijkheid van de hoeveelheid hooggeschoolde arbeid is kenmerkend voor horizontale FDI omdat het bij ongelijke relatieve hoeveelheden volgens het model gunstiger wordt voor de onderneming om productie volledig te concentreren in het land dat over relatief minder hooggeschoolde arbeid beschikt en het hoofdkantoor in het land met relatief veel hooggeschoolde arbeid (verticale FDI). Hogere investeringskosten in het ene bestemmingsland ten opzichte van een ander leidt tot meer FDI in het tweede land (OLS-resultaten en in overeenstemming met de theoretische voorspelling). Echter, een toename van de investeringskosten binnen één bestemmingsland over de tijd heeft niet dit effect (*multilevel*). Handelskosten in het land van bestemming tenslotte hebben geen eenduidig effect op FDI. Volgens de theoretische voorspellingen leiden hogere handelskosten in een land van bestemming tot meer FDI als substituut voor export. Maar verschillende specificaties leveren verschillende resultaten op.

In Hoofdstuk 5 testen we de robuustheid van de empirische specificatie van het *knowledge-capital model* met de OESO-data. In hoeverre laten de data het opleggen van de lineaire restricties toe? En hoe geschikt is de lineaire vorm van het model? We vinden dat de lineaire restrictie dat de coëfficiënten van de relatieve hoeveelheid hooggeschoolde arbeid in het land van oorsprong en het land van bestemming gelijk maar tegengesteld zijn, die dient om de voorspelling van het model dat verschillen in relatieve hoeveelheden hooggeschoolde arbeid aanleiding geven tot verticale FDI vast te leggen, wordt verworpen door de data. Een specificatie waarin de relatieve hoeveelheid hooggeschoolde arbeid in het land van oorsprong en het land van bestemming afzonderlijk worden geschat lijkt dus gepaster. Ook is een loglineaire model een meer geëigende functionele vorm. Het transformeren van de data verandert echter de specificatie, die vervolgens de voorspellingen van het *knowledge-capital model* niet langer exact weergeeft. Op basis van het empirisch bewijs in dit hoofdstuk verwerpen we het *knowledge-capital model* als model om bilaterale FDI van de OESO te verklaren. Hoofdstuk 5 schat vervolgens een graviteitsmodel van bilaterale FDI. Dit houdt in dat we niet langer onderscheid maken tussen horizontale en verticale FDI, maar dat we in plaats daarvan beogen het algemene patroon van bilaterale FDI van de OESO te verklaren. Wat betreft de factor geschoolde arbeid kijken we naar het aandeel hooggeschoolde arbeid in de beroepsbevolking en naar *human capital*. Vervolgens breiden we de graviteitsvergelijking uit met BNP per hoofd van de bevolking (een indicator voor het niveau van ontwikkeling) en institutionele kwaliteit. De reden is als volgt. Rijke, ontwikkelde landen hebben doorgaans ook een hoog niveau van *human capital* en/of grote hoeveelheden hoogopgeleide arbeid. Dit betekent dat, wanneer we niet controleren voor het niveau van ontwikkeling, de resultaten voor geschoolde arbeid vertekend kunnen zijn. Vanuit eenzelfde gedachte nemen we institutionele kwaliteit op gebaseerd op lessen uit de empirische literatuur over internationale handel dat het weglaten van institutionele kwaliteit de schatters van BNP per hoofd van de bevolking in de graviteitsvergelijking vertekent. We vinden positieve effecten op FDI van geschoolde arbeid, niveau van ontwikkeling en institutionele kwaliteit tezamen, ondanks econometrische problemen om ieder effect afzonderlijk te identificeren. We leiden daaruit af dat geschoolde arbeid, niveau van ontwikkeling en institutionele kwaliteit elk aannemelijke determinanten van FDI zijn. We vinden dat geschoolde arbeid, niveau van ontwikkeling en institutionele kwaliteit in zowel het land van oorsprong als het land van bestemming een positieve invloed op FDI hebben. Deze resultaten suggereren dat 'nabijheid' van oorspong- en bestemmingslanden in termen van hoeveelheden en/of kwaliteit van geschoolde arbeid, institutionele kwaliteit en niveau van ontwikkeling in het algemeen essentieel is in het verklaren van bilaterale FDI: multinationals kiezen bestemmingen die lijken op het land van oorsprong. Onze bevindingen ten aanzien van geschoolde arbeid wijzen er ten eerste op dat multinationals ontstaan in landen met relatief grote hoeveelheden hooggeschoolde arbeid en/of een hoog niveau van *human capital* en dat dit ook bepaalt waarom ze het ene land verkiezen boven een ander als locatie van hun buitenlandse activiteiten. Dit past in het beeld van multinationals als kennisintensieve bedrijven met veelal hoogwaardige productietechnologieën. Dit laatste vergt dat een ontvangend land over voldoende geschoolde arbeid en/of *human capital* beschikt om de kennisintensieve productie te kunnen opnemen. Multinationals kiezen ook locaties die figuurlijk dichtbij zijn namelijk in termen van de kwaliteit van het bestuurlijke systeem. De keuze van een onderneming van een geschikte locatie wordt bepaald door kosten. De kosten – aanpassingskosten en kosten door bijkomend gebrek aan onderling vertrouwen en vertrouwen in de zekerheid van transacties – zullen lager zijn naarmate de verschillen in het institutionele kader tussen het land van oorsprong en het bestemmingsland geringer zijn. Het belang van het niveau van ontwikkeling voor FDI kan enerzijds verklaard worden door geschoolde arbeid en institutionele kwaliteit. Rijke, ontwikkelde landen doorgaans ook degene met een hoog niveau van *human capital* en/of grote hoeveelheden hoogopgeleide arbeid alsmede instituties van hoge kwaliteit. Onder verwijzing naar de empirische literatuur over economische groei (Hoofdstuk 2) nemen we hier aan dat de causaliteit van geschoolde arbeid en instituties naar ontwikkeling loopt en niet andersom. Anderzijds kan het niveau van ontwikkeling ook de 'kwaliteit' van de vraag weergeven (inkomensgerelateerde patroon van de vraag). In dit geval heeft ontwikkeling een eigen effect op FDI. In dit geval doet nabijheid er opnieuw toe, dit keer in termen van de structuur van productie en de vraag.

Hoofdstuk 6 onderzoekt het effect van verschillende dimensies van afstand op de keuze tussen export en FDI als alternatieve manieren voor een bedrijf om een buitenlandse markt te bedienen. Zoals gezegd, de conventionele *proximity-concentration trade-off* hypothese stelt dat FDI toeneemt naarmate de afstand tussen twee landen groter wordt, terwijl andersom export belangrijker wordt wanneer schaalvoordelen in productie toenemen. Hoofdstuk 6 breidt het empirische raamwerk voor het analyseren van de afruil tussen export en FDI uit. Onze benadering houdt expliciet rekening met immateriële barrières die te maken hebben met culturele en institutionele verschillen tussen landen. Anders dan de mechanismen die worden beschreven in de *proximity-concentration* hypothese beïnvloeden deze niet-tastbare barrières de kosten van zowel FDI als handel. We schatten graviteitsvergelijkingen voor totale buitenlandse afzet (export plus productie voortkomend uit FDI van land i naar land j) en het aandeel van productie samenhangend met FDI in de totale afzet van land i naar land j. De OESO-data die we in deze studie gebruiken betrekking hebben op FDI-voorraden. Voor de analyse is de FDI-voorraad omgezet naar een maatstaf voor productie door gebruik te maken van de kapitaalintensiteit van productie. We laten zien dat verschillende dimensies van afstand een verschillende invloed hebben op export en FDI. In de eerste plaats is er een duidelijk bewijs voor de conventionele afruil tussen nabijheid en concentratie: het aandeel van productie samenhangend met FDI in de totale afzet neemt toe voor zowel geografische afstand als importtarieven. Aan de andere kant laat dit hoofdstuk zien dat FDI niet slechts een substituut is voor handel voor het geval dat transportkosten en handelsbarrières hoog zijn. FDI brengt eigen kosten met zich mee. Deze kosten zijn veelal van een immateriële aard. Het aandeel van FDI in de totale afzet neemt af voor taalverschillen en culturele afstand, een stijgt voor institutionele kwaliteit in zowel het oorsprong- als bestemmingsland. We duiden institutionele en culturele factoren aan als de ‘zachte’ dimensies van afstand. ‘Zachte’ barrières zijn dus vooral belangrijk voor FDI. Ze zijn vooral van invloed op FDI omdat lokale aanwezigheid een diepere betrokkenheid met en blootstelling aan lokale culturen en instituties inhoudt. Ook zijn de eisen die aan taal worden gesteld bij productie in een buitenlandse markt hoger dan voor export.

We kunnen nu de balans opmaken met betrekking tot de vraag waarom sommige landen zo veel FDI aantrekken, terwijl andere slechts kleine hoeveelheden aantrekken. Met andere woorden, welke factoren zijn bronnen van aantrekkingskracht van FDI? De relevante bijdragen in dit opzicht staan in Hoofdstukken 2, 5 en 6. We hebben gekeken naar de rol van geschoolde arbeid, niveau van ontwikkeling, institutionele kwaliteit en cultuur. We vinden dat geschoolde arbeid, niveau van ontwikkeling en institutionele kwaliteit in zowel het land van oorsprong als het land van bestemming een positieve invloed op FDI hebben. Culturele afstand beïnvloedt FDI negatief. We controleren bij dit alles voor de invloed van BNP. Marktomvang speelt in alle gevallen een belangrijke rol voor FDI. We concluderen dat nabijheid in termen van geschoolde arbeid, niveau van ontwikkeling, institutionele kwaliteit en cultuur tussen landen belangrijke bronnen van aantrekkingskracht voor FDI vormen. De analyse in Hoofdstuk 2 suggereert dat het effect van geschoolde arbeid en *human capital* op FDI kan verschillen per sector. Het hoofdstuk laat zien dat *human capital* en technische vaardigheden belangrijker zijn voor het aantrekken van FDI in *high-tech* sectoren dan voor totale FDI.

Op dit punt beland keren we terug naar de achtergrondvragen die aan het begin van deze samenvatting werden geformuleerd. Welk effect heeft FDI op de wereldwijde verdeling van economische activiteit? Leidt FDI tot een verdere samenklontering van economische activiteit in de bestaande centra en daarmee tot toenemende verschillen tussen landen? Of bevordert het een meer gelijkmatigere spreiding van economische activiteiten wereldwijd? In het licht van onze resultaten vermoeden wij dat het effect van FDI door de bank genomen meer in de richting van het eerste zal zijn. Dat wil zeggen: FDI zal eerder leiden tot een verdere clustering van economische activiteit in de bestaande centra. Deze studie toont aan dat massa, dat wil zeggen marktomvang zowel als absorptievermogen, waarbij het laatste gedefinieerd kan worden in termen van geschoolde arbeid, institutionele kwaliteit en of het ontwikkelingsniveau in algemene zin, en nabijheid, hetzij in termen van instituties, cultuur of inkomensgerelateerde productie- en vraagpatronen, belangrijke drijfveren van FDI zijn. Deze factoren verklaren waarom FDI zich vooral afspeelt tussen ontwikkelde, rijke landen. Op grond van deze studie kunnen we stellen dat FDI eerder de reeds bestaande patronen van economische geografie volgt dan dat het deze patronen verandert of zelf een nieuwe geografie vormgeeft. Dit impliceert tevens dat het potentieel van FDI als instrument om de inkomensachterstand van ontwikkelingslanden te verminderen beperkt is (zie hieronder).

Beleidsimplicaties

Vanuit beleidsperspectief onderstrepen de resultaten van deze studie het belang van investeringen in scholing en goede instituties voor het aantrekken van FDI. Opleiding en instituties zijn door mensen ingesteld en kunnen daarmee tot uitgangspunt van beleid worden gemaakt. Goede instituties en een hoogopgeleide beroepsbevolking verhogen de instroom van FDI en daarmee de mogelijkheid om te profiteren van de voordelen van FDI. FDI kan een direct effect op de welvaart in het bestemmingsland hebben door het niveau van investeringen te verhogen. Daarnaast wordt FDI vaak beschouwd als een middel van technologieoverdracht. Voor de meeste landen geldt dat buitenlandse technologie de belangrijkste bron van productiviteitsgroei is. Directe of indirecte interactie met bedrijven uit technologisch ontwikkelde landen is dan cruciaal om toegang te krijgen tot geavanceerdere kennis. Middels (al dan niet bewuste) kennisdiffusie naar lokale bedrijven kan FDI het productiviteitsniveau in bestemmingslanden verhogen. Maar onze resultaten impliceren ook dat de voordelen van FDI zich waarschijnlijk beperken tot de ontwikkelde landen. Deze landen beschikken reeds over goede onderwijssystemen en de 'juiste' institutionele kaders. Landen die daarentegen het meest van FDI zouden kunnen profiteren, te weten de minst ontwikkelde landen, kunnen dit wellicht niet omdat ze op voorhand niet in staat zijn FDI aan te trekken. Investeringen in onderwijs en instituties zijn kostbaar en het duurt lang voordat ze tot verbeteringen leiden. Daarnaast wordt institutionele verandering in deze landen vaak geremd door culturele en geografische barrières (afstand, topologie en klimaat) die moeilijk te doorbreken zijn. Deze studie laat daarmee zien dat het potentieel van FDI als middel voor economische ontwikkeling in de minst ontwikkelde landen beperkt is (zie beneden).

Investeren in *human capital* is ook belangrijk voor het land van origine. Vanuit de bestaande theorie wordt FDI tussen twee landen met veel geschoolde arbeid veelal gezien als horizontale FDI. Maar onderzoek over Amerikaanse multinationals laat zien dat deze bedrijven bij het verplaatsen van verschillende soorten productie naar het buitenland (verticale FDI) gebruik van het comparatieve voordeel van het partnerland. Ze kiezen partnerlanden met relatief veel geschoolde arbeid in kennisintensieve sectoren en landen met relatief veel ongeschoolde arbeid in arbeidsintensieve sectoren. Multinationals zoeken bij verticale FDI relatief goedkope arbeid, maar dat betekent niet dat ze per definitie laaggeschoolde arbeid zoeken. Het hangt van de industrie af. Uit onderzoek van het Internationaal Monetair Fonds (IMF) blijkt dat de instroom van FDI in zowel ontwikkelde landen als ontwikkelingslanden zich veelal concentreert in kennisintensieve sectoren. Dit houdt in dat eventuele verticale FDI ook plaatsvindt in kennisintensieve sectoren. Het bewaren van een hoog opleidingsniveau (door training en onderwijs) is dus niet alleen van belang is voor het ontstaan van multinationals in een land, maar is tevens belangrijk met het oog op het behouden van hoogwaardige productie in de thuismarkt. Dit is vooral van belang in de toekomst. Volgens het IMF is de intensiteit van het verplaatsen van delen van het productieproces naar het buitenland vooralsnog gering en zijn het binnen de kennisintensieve sectoren vooral de minst kennisintensieve activiteiten die worden verplaatst. Maar met een toenemend reservoir aan geschoolde arbeiders in met name Azië, is er voor het Westen geen reden tot onbekommerd achteroverleunen.

Een derde beleidsimplicatie van deze studie, en gerelateerd aan het vorige punt, is dat de gevolgen van FDI voor de arbeidsmarkt in het land van origine op basis van de bestaande theorie wellicht onderschat worden. In het *knowledge-capital model* wordt FDI tussen twee landen met veel geschoolde arbeid veelal gezien als horizontale FDI. Bij horizontale FDI hebben multinationals per definitie productiefaciliteiten in het buitenland naast productie in de eigen thuismarkt. Maar, zoals hierboven is geschetst, het onderscheid tussen horizontale en verticale FDI op basis van de hoeveelheid hooggeschoolde arbeid die er voor nodig is, is in de praktijk wellicht niet zo scherp. Deze studie verwerpt het *knowledge-capital* model op empirische gronden. We schatten een graviteitsmodel. Het graviteitsmodel maakt geen onderscheid tussen horizontale en verticale motieven voor FDI. Om de werkgelegenheidseffecten van FDI in het land van oorsprong te kunnen vaststellen moeten we voorbij het algemene model kijken. Dit vereist inzicht op het niveau van ondernemingen.

De studie besluit met een aantal suggesties voor mogelijk vervolgonderzoek. Deze hebben betrekking op een analyse van FDI op sectorniveau, de theoretische onderbouwing voor de graviteitsvergelijking voor FDI, de werkgelegenheidseffecten van FDI en het effect van de verschillende dimensies van afstand over tijd.